
INTERIM MEASURES WORK PLAN ADDENDUM EAST HELENA FACILITY

Prepared for:

ASARCO Incorporated
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East Helena, Montana 59635

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April 2002

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INTERIM MEASURES WORK PLAN ADDENDUM

EAST HELENA FACILITY

1.0 INTRODUCTION

In 1997, EPA initiated a transfer of responsibility for on-going remedial activities at the Asarco East Helena Facility from its CERCLA program to a corrective action program under the Resource Conservation and Recovery Act (RCRA). A Consent Decree effective May 5, 1998 between EPA and Asarco (U.S. District Court, 1998) initiated the corrective action process in accordance with the RCRA program.

The initial requirement of the RCRA program was to prepare a Current Conditions/Release Assessment (CC/RA) report, which was completed by Asarco in September 1998 and approved by EPA in February 1999. The CC/RA summarized historical environmental studies and provided an evaluation of current conditions. Based on a review of the CC/RA, EPA determined interim measures were required for the groundwater, the acid plant, and the Lower Lake sediments and other stockpiled soils (USEPA 1999). In response, Asarco completed an Interim Measures (IM) Work Plan, which was approved by EPA on August 26, 1999. With the exception of continuing groundwater investigations, including the ongoing testing of the air sparging system, the tasks specified in the Interim Measures Work Plan have been completed.

Concurrent with the Interim Measures work, Asarco initiated a RCRA Facility Investigation (RFI) to further characterize the nature and extent of historical releases and provide a basis for assessing corrective measures. The RFI work plan was approved by EPA on January 30, 2001 and the RFI field investigation was implemented during the summer and fall of 2001. As part of the RFI field investigation, Asarco installed a groundwater monitoring well in the intermediate aquifer (DH-64) at the northern boundary of the plant site and sampled all existing monitoring wells and known

residential wells within the City of East Helena. The December 2001 sampling revealed elevated arsenic concentrations in the intermediate aquifer on the northwestern edge of the plant site and in an adjacent monitoring well (EH-100) northwest of the site. Prior to this time, elevated arsenic concentrations had not previously been identified in the intermediate aquifer.

Since there are residential wells completed within the intermediate aquifer in the City of East Helena, the RFI results raised concerns about the potential for impacts to domestic wells. While all samples collected as part of the RFI from residential drinking water wells located down gradient of the plant (including the samples collected in December 2001), showed metal and arsenic concentrations to be below the state and federal drinking water standards, the long-term susceptibility of these wells to contamination could not be established. To address this concern, EPA directed Asarco to develop a work plan that provides for 1) additional hydrological characterization of the intermediate aquifer, 2) a regular, frequent sampling program for all potentially affected active private wells, 3) a plan for offering to connect those presently using private wells for consumption and irrigation to the East Helena water distribution system, and 4) alternatives for additional action if contamination reaches these wells. This Interim Measures Work Plan Addendum is intended to provide a procedure to achieve these objectives.

1.1 EXISTING CONDITIONS

Asarco's 2001 RFI field investigation provided updated information on water quality trends and additional information on the aquifer stratigraphy, groundwater flow directions and status of residential wells within the area down gradient of the Asarco East Helena Site. A summary of RFI results is provided below as background to this Work Plan.

1.1.1 Hydrostratigraphy

Plant site stratigraphic relationships were previously described and illustrated on cross-sections in the RI/FS (Hydrometrics 1990), CC/RA (Hydrometrics 1999a), and the IM Supplemental Groundwater report (Hydrometrics 2000a). Updated cross sections are

shown in Exhibit 1. Hydrostratigraphic units defined for the plant site and surrounding East Helena area include:

- Upper Alluvial Aquifer: The Upper Alluvial Aquifer is the first continuous zone of saturated unconsolidated sediments and typically consists of the upper 8 to 15 feet of saturated alluvium.
- Intermediate Alluvial Aquifer: The Intermediate Alluvial Aquifer is the next water producing zone (typically sand and gravel alluvium) below the Upper Alluvial Aquifer. The Intermediate Alluvial Aquifer is usually (but not consistently) separated from the Upper Alluvial Aquifer by a thin (1 to 3 feet) fine-grained clay or silt layer, and is typically more than 10-15 feet below the shallow aquifer water table. An underlying Ash/Clay Unit dips to the north and east resulting in a thicker sequence of intermediate alluvial aquifer material north of the plant site. Monitoring wells EH-64 and EH-100 (Exhibit 1) fully penetrate the intermediate aquifer.
- Tertiary Ash/Clay Unit: The Upper Alluvial Aquifer and the Intermediate Alluvial Aquifer are underlain by an Ash/Clay Unit. The Ash/Clay Unit is typically 20 feet or more in thickness under the plant site. With the exception of a few locations, the depth and thickness of the ash unit have not been well established in the East Helena area north of the plant site.
- Deep Aquifer: The Deep Aquifer includes the water bearing zones in deeper horizons of the Ash/Clay Unit, sand or gravel materials below the fine-grained Ash/Clay Unit, or bedrock aquifers beneath the Ash/Clay Unit.

1.1.2 Groundwater Quality

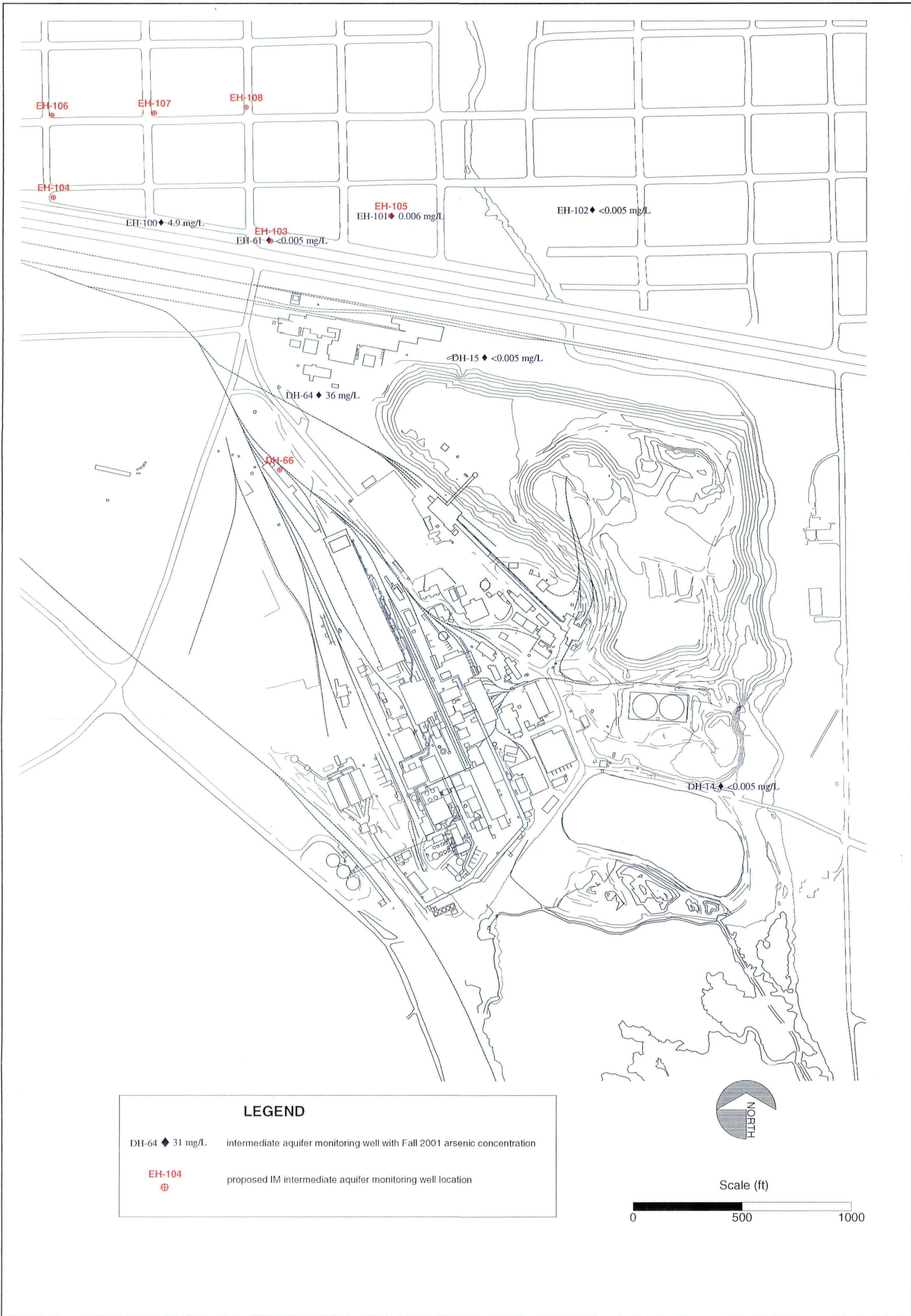
Groundwater quality in the plant site area is variable and reflects impacts from previously identified source areas. Historically, groundwater on the west half of the plant site has been strongly influenced by the former acid plant water treatment facility and sediment drying area, and the former speiss pond and pit. Water on the east side of the plant has been affected by Lower Lake.

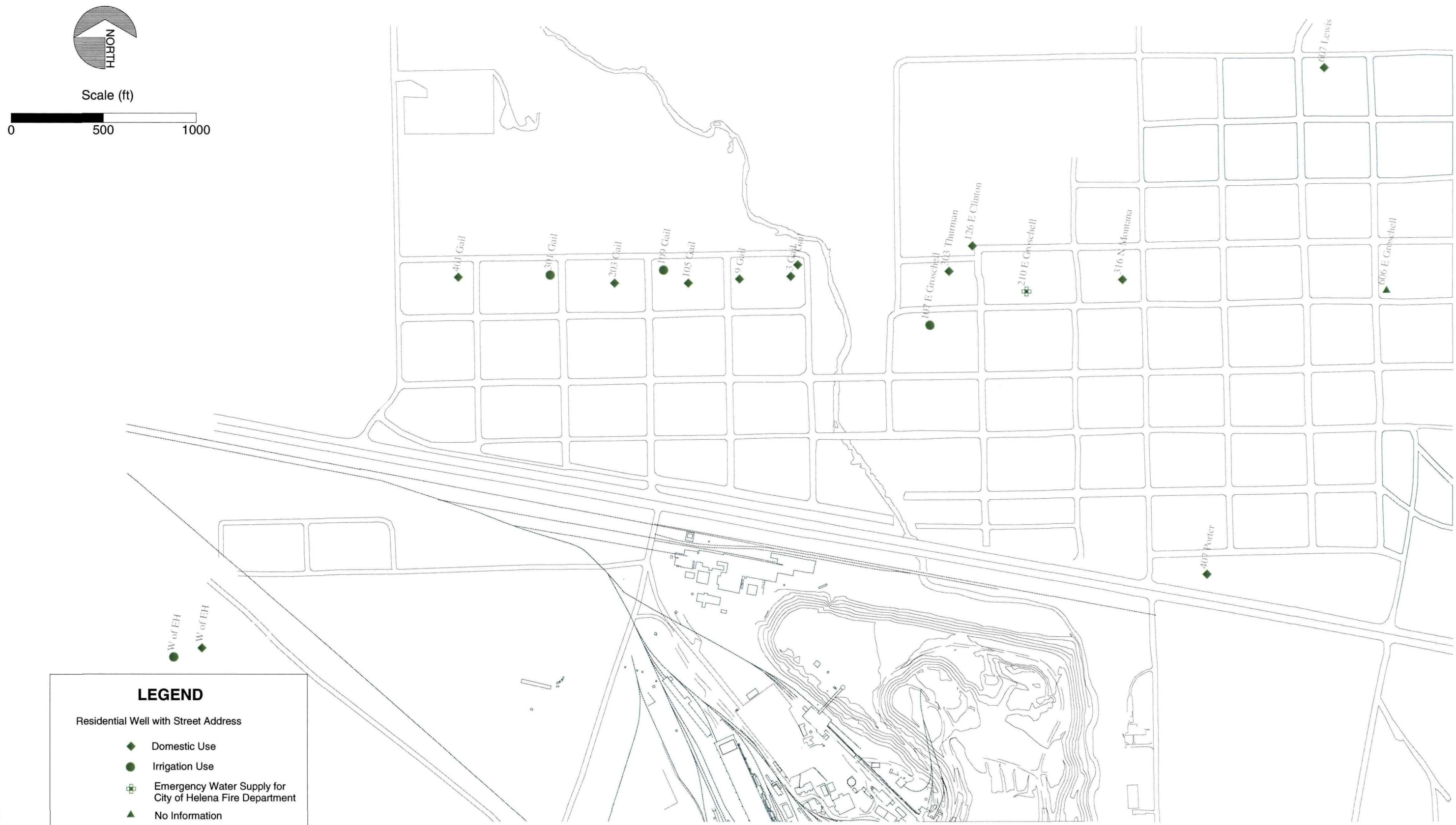
Arsenic is the only constituent that is detected in off-site shallow monitoring wells at concentrations in excess of federal and state drinking water standards. The current distribution of arsenic in shallow groundwater is depicted in Figure 1-1. Arsenic concentrations in the intermediate aquifer are shown in Figure 1-2. There are presently insufficient data to define arsenic plume contours in the intermediate system. Arsenic is not elevated in the deep aquifer.

1.1.3 Residential Well Water Quality

The City of East Helena has implemented a well ban in the area serviced by the municipal water supply that prohibits the installation of additional private wells. Most homes in the City are connected to the municipal water supply. However, there are still a number of residential wells currently in use within the City limits. Asarco inventoried and sampled these wells as part of the 2001 RFI investigation. The locations of existing residential wells and the status of their use are shown in Figure 1-3. Although the majority of the residential wells are not in use or are used exclusively for irrigation purposes, there are several wells used as the residential water supply. Residential wells are primarily completed in the intermediate and deep aquifers.

Asarco has been monitoring water quality semi-annually in representative private wells since 1989. In addition, all accessible residential wells (regardless of operating status) were sampled in 2001 as part of the RFI. The water quality results show that all of these wells meet water quality standards (including the recently lowered arsenic standard of 0.010 mg/L), with the exception of one shallow hand-dug well within the City limits and one well to the west of the plant site. Arsenic concentrations in the shallow, hand-dug well within City limits have been consistently elevated since monitoring began in the late 1980s, but there has been no indication of an increasing trend. The well to the west of the plant site is lateral to the impacted groundwater flowpath from the facility, and although the arsenic concentrations observed in this well are slightly above the new standard for arsenic, the concentrations are typical of background concentrations in local groundwater.





K:/Project/1054/Work Plan/Fig1-3.srf

2.0 WORK PLAN OBJECTIVES AND SCOPE

2.1 OBJECTIVES

The overall objectives of this Work Plan are to 1) determine the extent of elevated arsenic concentrations in the intermediate groundwater system, 2) provide expanded monitoring of active residential wells within the City of East Helena, 3) describe the plan for offering to connect those presently using private wells for consumption and irrigation to the East Helena water supply, and 4) consider alternatives for additional action if contamination reaches these wells.

Objective 1 includes:

- Collection of data to define the boundary of the arsenic plume in the intermediate aquifer;
- Installation and sampling of intermediate monitoring points between the arsenic plume and any existing residential wells; and
- Evaluation of the vertical distribution of arsenic concentrations in intermediate aquifer groundwater, to establish whether it is uniformly distributed or localized within discrete higher permeability zones.

Objective 2 includes:

- Collection and analysis of groundwater from residential wells that are used for drinking water and irrigation water supplies; and
- Communication of the well sampling program results to the residents.

Objective 3 includes:

- Meet with community to discuss alternatives to the use of groundwater wells for drinking and irrigation water supplies;

- Provide notification to affected residential well owners offering to connect homes to the City of East Helena municipal water supply; and
- Abandonment of replaced water supply wells.

Objective 4 includes:

- Evaluation of alternative water supply sources; and
- Verification sampling for results that indicate contamination may have reached residential wells.

2.2 SCOPE OF WORK

This Work Plan provides the methodology and procedures for each task discussed in the referenced Work Plan section. The follow tasks will be conducted to meet the work plan objectives:

- Task 1.* Characterization of intermediate alluvial aquifer groundwater, including:
 - Installation, development and sampling of seven additional monitoring wells in the north plant site and East Helena area (Section 3.1).
 - Aquifer testing of selected monitoring wells (Section 3.1.6).
- Task 2.* Bi-monthly monitoring of East Helena residential water supply wells that remain in use (Section 3.2) and communication of results of the sampling program with the residents.
- Task 3.* Communication and provision of alternative water supply sources (Section 3.3) including:
 - Community meetings to discuss water use alternatives;
 - Written notification of residences offering replacement of existing groundwater well supplies with City of East Helena municipal supply; and

- Connection of residential well users to the City of East Helena municipal water supply and abandonment of existing water supply wells (Section 3.3).

Task 4. Evaluation and action alternatives if contamination reaches residential water supplies (Section 3.4) including:

- Supplemental verification monitoring; and
- Providing bottled water.

A summary report presenting findings of the intermediate alluvial groundwater investigation will be prepared as described in Section 5.0.

3.0 FIELD INVESTIGATION METHODOLOGY

3.1 GROUNDWATER CHARACTERIZATION

The intermediate alluvial aquifer groundwater investigation will consist of monitoring well installation, surveying, development, and sampling. Procedures for each of these activities are presented in Sections 3.1.1 through 3.1.6.

3.1.1 Well Installation

Seven groundwater monitoring wells will be installed in the intermediate alluvial aquifer. Preliminary monitoring well locations are shown in Figure 1-2 and anticipated construction details for the wells are summarized in Table 3-1.

Some of the proposed intermediate monitoring wells are co-located with existing intermediate aquifer wells (EH-103 and EH-105 for example). The proposed wells will be completed at the base of the intermediate aquifer with the bottom of the well at the intermediate aquifer/ash unit contact. Groundwater sample data from the proposed intermediate wells will augment data collected from the existing intermediate aquifer monitoring wells (EH-61 and EH-102) completed in the upper portion of the intermediate aquifer.

Water samples will be collected at the time of drilling and submitted for rapid-turnaround analysis of dissolved arsenic. Based on arsenic results, subsequent well locations may be adjusted to better document the plume extent.

Monitoring wells will be drilled using an ODEX or air rotary drilling system. Soil samples will be collected at 5-foot intervals using a 3-inch diameter split spoon sampler. Soil samples collected during drilling will be analyzed for total arsenic and metals using XRF techniques to help identify distribution of contaminants in the aquifer. The soil sample and analytical matrix is in Table 3-2. Lithology will be logged in the field during drilling by an experienced hydrogeologist. Well logs will be compiled documenting geology and well construction details for each well. Drilling typically generates small

TABLE 3-1. ANTICIPATED CONSTRUCTION FOR INTERMEDIATE GROUNDWATER MONITORING WELLS

Location	Well Name	Casing Size (inches)	Evaluation Area	Approximate Ground Surface Elevation (feet)	Approximate Average Water Elevation (feet)	Approximate Ash Surface Elevation (feet)	Anticipated Total Depth (feet)	Anticipated Screen Interval (ft bgs)
North Plant Site	DH-66	2	Downgradient of Lower Ore Storage Area	3900	3867	3853	47	32 - 47
City of East Helena	EH-103	2	Immediately north of Highway 12	3886	3865	3828	58	43 - 58
	EH-104	2	Immediately north of Highway 12	3883	3855	3828	55	40 - 55
	EH-105	2	Immediately north of Highway 12	3874	3862	3827	47	32 - 47
	EH-106	2	Midpoint between Highway 12 and Gail Street	3880	3841	3810	70	55 - 70
	EH-107	2	Midpoint between Highway 12 and Gail Street	3881	3845	3810	71	56 - 71
	EH-108	2	Midpoint between Highway 12 and Gail Street	3878	3847	3810	68	53 - 68

Note: Listed casing size is inside diameter. All borings to be completed as monitoring wells

Monitoring wells will be constructed so that the screen length is equal to 15 feet.

ft bgs = feet below ground surface

Elevations in feet above mean sea level

TABLE 3-2. SUBSURFACE SOIL SAMPLE COLLECTION AND ANALYSIS MATRIX FOR INTERMEDIATE MONITORING WELLS

Sample Location	Purpose	Sample Types and Depth Intervals ⁽¹⁾	Number of Sampling Events	Total Non-QC Samples	Analytical Parameters	Laboratory Methods	Project Detection Limit Goal	Field QC Duplicates ⁽²⁾	Total Samples
<u>Monitoring Well</u> <u>Boreholes</u> DH-66 EH-103 EH-104 EH-105 EH-106 EH-107 EH-108	(1) Define the extent of elevated arsenic concentrations in groundwater from the intermediate aquifer. (2) Evaluate potential sources and the risk of impacts to residential wells in the City of East Helena.	Continuous 2' split spoons to 12', 5' intervals from 15' to total depth	1	93	As Cd Cu Fe Mn Pb Zn	XRF XRF XRF XRF XRF XRF XRF	10 ppm 10 ppm 10 ppm 20 ppm 30 ppm 10 ppm 10 ppm	5	98
TOTAL XRF SAMPLES									98

(1) Sample depths are approximate; actual depths will be based on field conditions. Number of samples calculated assuming monitor well borehole depths are as listed in Table 3-1 of the IM Work Plan Supplement.

(2) Duplicates will be collected at a minimum frequency of 1 per 20 field samples.

quantities of soils. Excess drill cuttings and soils will be collected and placed on the Asarco-owned east fields where residential soils are managed as part of the CERCLA Administrative Order on Consent.

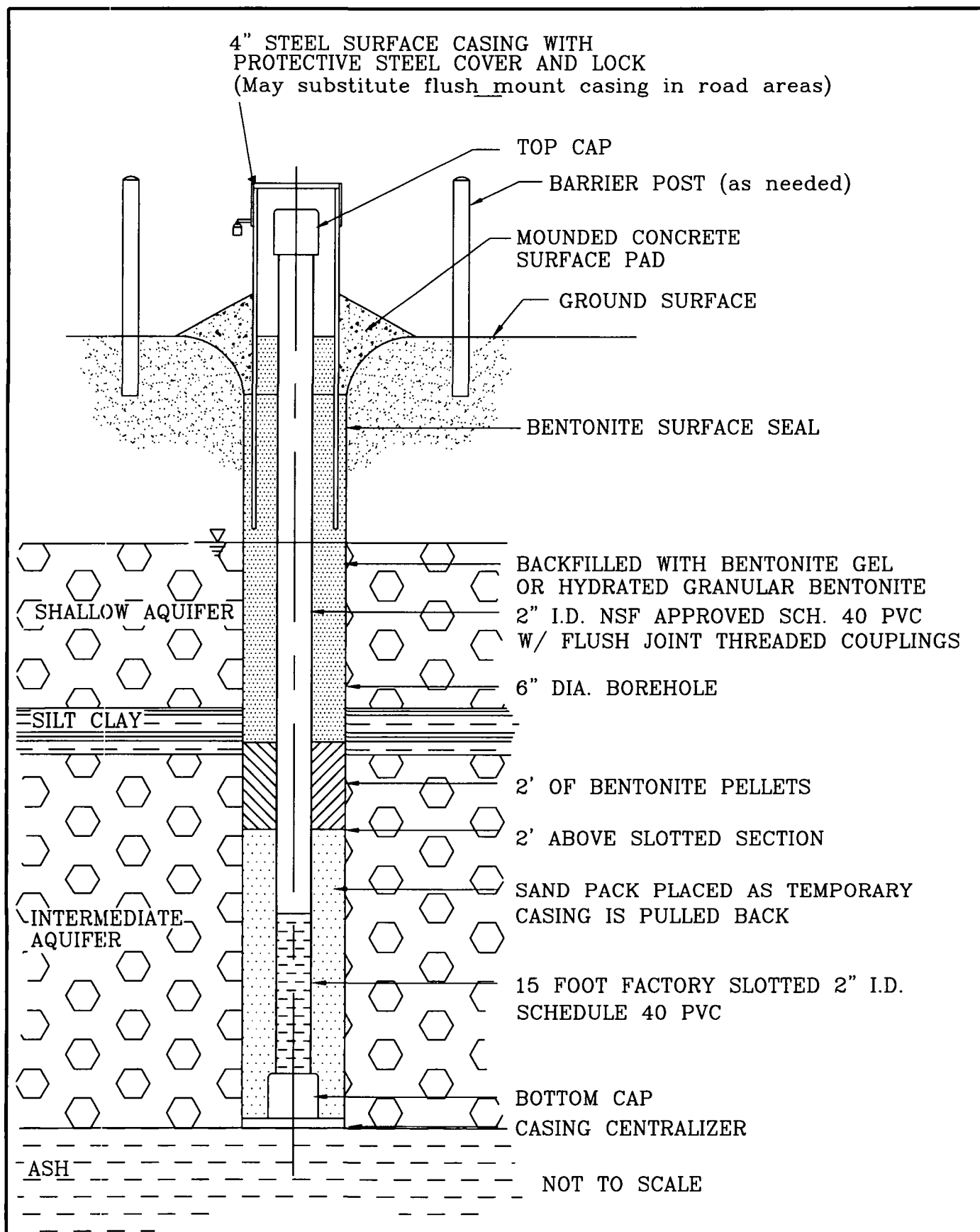
All wells will be completed with 2-inch, schedule 40, polyvinyl chloride (PVC) casing with flush threaded joints. The wells will be completed to the top of the previously described Ash/Clay Unit, and screened using 15 feet of 0.010-inch factory slotted well screen. The screened interval will be sand packed and grouted to meet Montana monitoring well standards as defined in ARM 36.21. Surface completions will consist either of flush-mounted or stickup-type steel protective casings, depending on the location of individual wells. A typical well completion diagram is shown in Figure 3-1.

3.1.2 Well Surveying and Water Level Measurement

Following drilling and development, all IM monitoring wells will be surveyed vertically and horizontally. An elevation in feet above mean sea level (MSL) for the top of the casing (TOC) measuring point (MP) will be determined for each well so that the monitoring well network is referenced to a common datum. Depths to groundwater will be measured from the TOC measuring point, and static groundwater levels will be converted to elevations in feet above mean sea level.

3.1.3 Well Development and Sampling

Following completion, monitoring wells will be developed using a submersible pump or a bailer to reduce turbidity, and to ensure good hydraulic continuity with the aquifer. Well development procedures (e.g., equipment, pumping/bailing rates, appearance of groundwater, etc.) will be recorded on a standard form. Turbidity will also be measured and recorded at regular intervals during well development to demonstrate turbidity reduction over time. Other groundwater quality parameters such as pH, specific conductance, and temperature may also be monitored to evaluate changes in water quality during development. In general, representative groundwater samples should have a turbidity of less than 5.0 NTU. Therefore, the goal of well development will be to reduce turbidity below the 5.0 NTU level. Purge water obtained from monitoring wells during



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TYPICAL INTERMEDIATE
WELL COMPLETION DIAGRAM

FIGURE

3-1



development will be containerized and discharged to the Asarco East Helena plant water treatment system.

Groundwater sampling will be conducted at all of the intermediate alluvial aquifer monitoring wells in the north plant site and East Helena area, including DH-15, DH-64, DH-66, and EH-100 through EH-108. A groundwater sampling and analytical matrix for the IM intermediate groundwater characterization is shown in Table 3-3, including the number of samples to be collected, sample locations, analytical parameters and methods, required detection limits, and field quality control sampling requirements. Two rounds of well sampling using traditional methods (in addition to the DMLS and low-flow sampling events described below) are planned for the suite of intermediate wells. In addition to this sampling program, the new intermediate monitoring wells may be integrated into the on-going semi-annual post-RI monitoring.

Sampling of monitoring wells will be conducted in accordance with applicable standard operating procedures (SOPs) previously approved for use on site investigations at the East Helena Facility, including implementation of the Interim Measures Work Plan (Hydrometrics, 1999b) and the RFI Work Plan (Hydrometrics, 2000a). In addition, SOPs are provided for a number of procedures that will be used during implementation of the IM Work Plan Addendum, but have not been presented in previous work plans, specifically, low-flow sampling, discrete multi-layer sampling, and pneumatic slug testing. Relevant SOPs for groundwater quality sampling and investigation are listed in Table 3-4, and copies of SOPs are included in Appendix A. In general, sampling of monitoring wells will involve the following steps:

1. Measurement of static water level using a water level probe;
2. Calculation of the volume of water present in the well bore;
3. Purging the well until well purge criteria are met (criteria typically include removal of a minimum of three well bore volumes and/or stabilization of field parameters measured during purging);
4. Collection of water quality samples (using traditional, DMLS, or micropurge techniques); and
5. Decontamination of sampling equipment as necessary.

TABLE 3-3. INTERIM MEASURES INTERMEDIATE AQUIFER GROUNDWATER CHARACTERIZATION SAMPLE COLLECTION AND ANALYSIS MATRIX

Sample Location ⁽¹⁾	Purpose	Number of Sampling Events ⁽²⁾	Total Non-QC Samples	Analytical Parameters	Laboratory Methods ⁽⁴⁾	Project Detection Limit Goal (mg/L)	Field QC Samples ⁽⁵⁾					Total Samples
							Field Duplicates	Field Standards	Field Splits	Field D.I. Blanks	Field Rinsate Blanks	
Plant Site DH-64 (E) DH-66	(1) Define the extent of elevated arsenic concentrations in groundwater from the intermediate aquifer.	2 (Routine)	24	<u>Field Parameters</u> pH specific conductance (SC) dissolved oxygen temperature SWL (static water level)			6	2	3	6	6	131
North of Plant Site DH-15 (E)		1 (Low-Flow)	72									
City of East Helena EH-100 (E) EH-101 (E) EH-102 (E) EH-103 EH-104 EH-105 EH-106 EH-107 EH-108	(2) Evaluate potential sources and the risk of impacts to residential wells in the City of East Helena.	1 (DMLS)* <div>*NOTE: DMLS samples will be analyzed for arsenic only due to limited sample quantity.</div>	12	<u>Laboratory Parameters</u> <u>Common Constituents</u> pH SC Ca Mg Na K HCO ₃ SO ₄ Cl TDS Total Alkalinity as CaCO ₃ <u>Trace Constituents</u> ⁽³⁾ As (diss) Cd (diss) Cu (diss) Fe (diss) Mn (diss) Pb (diss) Zn (diss) As3+ As5+	150.1 120.1 6010A/7140 6010A/7450 6010A/7770 6010A/7610 310.1 9036 325.2 160.1 310.1 7060/6010A/6020 7131/7130/6010A/6020 7211/7210/6010A/6020 6010A 6010A 7421/7420/6010A/6020 7950/6010A/6020 7060/6010A/6020 7060/6010A/6020	 5 5 5 5 1 1 1 10 1 0.005 0.001 0.004 0.02 0.015 0.005 0.02 0.005 0.005						

(1) (E) = existing monitoring well; other wells installed during implementation of the IM Work Plan Addendum. Existing wells may be sampled as part of semiannual Post-R1 monitoring, depending on schedule.

(2) Sampling events will be conducted as follows:

[a] Routine monitoring event using traditional sampling methods (pump/bailer) will be conducted after new wells are developed.

[b] Wells with arsenic concentrations > 10 ppb based on initial sampling will be sampled at 2.5-foot intervals using low-flow techniques (6 samples per well based on 15-foot screen length).

[c] Two wells will be selected for sampling with discrete multi-layer samplers (DMLS) (6 samples per well)

[d] Second routine monitoring event conducted approximately 2-3 months after initial event.

(3) Trace constituents will be analyzed as dissolved concentrations. Samples will be field-filtered through a 0.45 µm filter prior to preservation.

(4) Methods from EPA's *Test Methods for Evaluating Solid Waste, SW-846* (1992) or *Methods for Chemical Analysis of Water and Wastes* (1983).

For trace constituents and major cations, Method 6010 is ICP, Method 6020 is ICP-MS, and other methods are flame or graphite furnace AA.

(5) Field duplicates and blanks will be collected at a minimum frequency of 1 per 20 field samples during routine and low-flow sampling events.

One field split (submitted to an alternate laboratory) will be collected during each of the routine monitoring events and the low-flow sampling event.

One field standard will be submitted with the groundwater samples for each routine monitoring event.

All sampling activities and field measurements will be recorded in a dedicated project notebook. Samples will be preserved in the field as appropriate for the designated parameters, assigned unique field identification codes, and labeled with the date and time of collection. All samples will be stored and shipped under well-defined chain-of-custody protocols to ensure sample integrity.

TABLE 3-4. FIELD INVESTIGATION STANDARD OPERATING PROCEDURES

SOP #	Title
HF-SOP-3	Preservation and Storage of Inorganic Water Samples
HF-SOP-4	Packing and Shipping Samples
HF-SOP-5	Chain-of-Custody
HF-SOP-7	Decontamination of Sampling Equipment
HF-SOP-9	Logging of Monitoring Well Geological Conditions, Construction, and Development
HF-SOP-10	Water Level Measurement with an Electric Probe
HF-SOP-11	Sampling Monitoring Wells for Inorganic Parameters
HF-SOP-20	Field Measurement of pH using a pH Meter
HF-SOP-22	Field Measurement of Dissolved Oxygen
HF-SOP-29	Labeling and Documentation of Samples
HF-SOP-31	Field Notebooks
HF-SOP-73	Filtration of Water Samples
HF-SOP-79	Field Measurement of Specific Conductance
HF-SOP-84	Field Measurement of Temperature
HF-SOP-99	Operation of Pneumatic Slug Tester
HF-SOP-105	Low Flow Sampling of Monitoring Wells for Inorganic Parameters
HS-SOP-13	Rinsate Blank Collection

NOTE: Copies of all tabulated SOPs are included in Appendix A.

3.1.4 Discrete Multi-Layer Sampling

As noted previously, groundwater quality sampling for this investigation will include an assessment of the vertical distribution of arsenic in groundwater. Based on the results of initial sampling conducted using traditional sampling techniques, EPA discrete multi-level samplers (DMLS) will be installed at two selected locations. The DMLS will be installed and sampled in accordance with the general sampling protocol previously used by EPA on the site. In addition, all of the intermediate alluvial aquifer monitoring wells with arsenic concentrations greater than the drinking water standard of 0.010 mg/L (10 µg/L) will be sampled at discrete 2.5-foot vertical intervals using a low-flow (micro-

purge) technique for comparison with DMLS and traditional sampling results (see Section 3.1.5 below).

Based on water quality results from preliminary sampling (Section 3.1.1), two monitoring wells will be selected for vertical water quality profiling in the central plume area using DMLS samplers. Protocols for use of the DMLS are included in Appendix B.

Each DMLS sampler consists of a 5-foot section of pipe containing 12 individual sampling cells. Three DMLS samplers connected with quick lock connectors will be used to sample the full screen length (15 feet) at each monitoring well. The top section will be fitted with a cable hook, and the entire assembly suspended in the screened interval of the well by means of a rope or cable tied off at the well head. Individual sampling cells will be filled with deionized water prior to DMLS placement. The DMLS samplers will be left in place for about 3 weeks.

For submittal to the laboratory, DMLS water samples will be composited over 2.5 foot intervals (i.e., two separate samples will be composited from each 5-foot section, by combining the contents of the top and bottom 6 sample cells). Due to the limited amount of sample collected by the DMLS, samples will be analyzed for arsenic concentrations only. Composited samples will be preserved in the field with nitric acid (HNO_3) to $\text{pH} < 2$ and submitted to the selected laboratory for analysis.

3.1.5 Micro-Purge Sampling

Intermediate monitoring wells exhibiting elevated arsenic concentrations ($>10 \mu\text{g/L}$) will be sampled at discrete vertical intervals using micro-purge or low-flow sampling techniques. This method will permit a greater number of wells to be sampled over a shorter time interval than DMLS sampling. In addition, unlike the DMLS, samples collected using the low-flow method are not limited in quantity and can therefore be analyzed for the full suite of parameters (Table 3-3). Six water samples will be collected from each well using low-flow methodology, at 2.5-foot intervals over the well screen length. The results will be compared to DMLS data and used to interpret the vertical

arsenic distribution within the aquifer. A description of the low-flow sampling method is included in Appendix A (HF-SOP-105).

3.1.6 Aquifer Testing

Aquifer testing will be conducted on all new IM monitoring wells (installed as part of this Work Plan) and selected existing site monitoring wells to estimate intermediate aquifer hydraulic parameters. The aquifer tests will be conducted as pneumatic (rising-head) slug tests, following well development. The procedure for conducting pneumatic slug tests is outlined in HF-SOP-99 (Appendix A). Aquifer test data will be analyzed using software such as AquiferTest from Waterloo Hydrogeologic.

3.2 RESIDENTIAL GROUNDWATER WELL MONITORING

All residential wells (identified in Table 3-5) that are down gradient of the plant site and currently in use will be sampled on a bi-monthly schedule, conditional upon approval of the well owners. Sample will start as soon as the Work Plan is approved. Based on current information, 16 wells will be included in the bimonthly residential groundwater monitoring program. A sampling and analytical matrix table summarizing the East Helena residential groundwater monitoring program is shown in Table 3-6. If water quality standards are exceeded in any residential wells, all of the residential wells in the affected area will be resampled and the results will be reviewed with EPA (see Section 3.4).

Residential well sampling will be conducted in accordance with applicable standard operating procedures (SOPs) previously approved for use on site investigations at the East Helena Facility, including implementation of the Interim Measures Work Plan (Hydrometrics, 1999b) and the RFI Work Plan (Hydrometrics, 2000a). Relevant SOPs for groundwater quality sampling and investigation are listed in Table 303 and copies of the SOPs are in Appendix A. In general residential well sampling procedures are the same as for monitoring well sampling with the exception that existing residential in-place pumping equipment, piping and plumbing will be used for well purge and sample collection. In addition, residential well sampling procedures will not include the use

Table 3-5 East Helena Private Water Wells in Active Use

Address	Well status	Use of well
107 East Groschell	Operating	Irrigation only
126 East Clinton	Operating	Drinking water and irrigation
126 East Clinton	Operating	Irrigation only
606 East Groschell	Operating	Drinking water and irrigation
1 Gail	Operating	Drinking water and irrigation
2 Gail	Operating	Drinking water and irrigation
9 Gail	Operating	Drinking water and irrigation
105 Gail	Operating	Drinking water and irrigation
109 Gail	Operating	Irrigation only
203 Gail	Operating	Drinking water and irrigation
301 Gail	Operating	Irrigation only
401 Gail	Operating	Drinking water and irrigation
607 Lewis	Operating	Drinking water and irrigation
316 North Montana	Operating	Drinking water and irrigation
407 Porter	Operating	Drinking water and irrigation
303 Thurman	Operating	Drinking water and irrigation
210 East Groschell	Operating	Emergency Water Supply for City of East Helena Fire Department
West of East Helena	Operating	Drinking water
West of East Helena	Operating	Drinking water
West of East Helena	Operating	Irrigation only

Highlighted wells are down-gradient residential wells that will be sampled (see Table 3-6).

TABLE 3-6. EAST HELENA RESIDENTIAL WELL GROUNDWATER SAMPLING AND ANALYTICAL MATRIX TABLE

Residential Well Address	Well Use	Purpose	Total Non-QC Samples Per Event ⁽¹⁾	Analytical Parameters	Laboratory Methods ⁽³⁾	Project Detection Limit Goal (mg/L)	Field QC Samples ⁽⁴⁾		Total Samples Per Event
							Field Duplicates	Field Rinsate Blanks	
107 East Groschell 126 East Clinton 126 East Clinton 606 East Groschell 1 Gail 2 Gail 9 Gail 105 Gail 109 Gail 203 Gail 301 Gail 401 Gail 607 Lewis 316 North Montana 407 Porter 303 Thurman	Irrigation only Drinking water and irrigation Irrigation only Drinking water and irrigation Drinking water and irrigation Drinking water and irrigation Drinking water and irrigation Irrigation only Drinking water and irrigation Irrigation only Drinking water and irrigation Drinking water and irrigation Drinking water and irrigation Drinking water and irrigation Drinking water and irrigation	Monitor arsenic concentrations in active residential wells in the City of East Helena on a routine basis to rapidly identify any impacts from upgradient sources.	16	<u>Field Parameters</u> pH specific conductance (SC) <u>Laboratory Parameters</u> <u>Common Constituents</u> SO ₄ TDS <u>Trace Constituents</u> ⁽²⁾ As (diss)	 9036 160.1 7060/6010A/6020	 1 10 0.002	1	1	18

(1) Sampling will be conducted bimonthly until characterization of the extent of arsenic concentrations in the intermediate aquifer is completed. Subsequently, the sampling schedule may be revised.

(2) Arsenic will be analyzed as dissolved concentrations. Samples will be field-filtered through a 0.45 µm filter prior to preservation.

(3) Methods from EPA's *Test Methods for Evaluating Solid Waste, SW-846* (1992) or *Methods for Chemical Analysis of Water and Wastes* (1983).

For trace constituents and major cations, Method 6010 is ICP, Method 6020 is ICP-MS, and other methods are flame or graphite furnace AA.

(4) Field duplicates and rinsate blanks will be collected at a minimum frequency of 1 per residential sampling event.

micro purge techniques or pumping equipment decontamination where the existing pumping systems are used for sample collection.

As described for monitoring well sampling, all residential well sampling activities and field measurements will be recorded in a dedicated project notebook. Samples will be preserved in the field as appropriate for the designated parameters, assigned unique field identification codes, and labeled with the date and time of collection. All samples will be stored and shipped under well-defined chain-of-custody protocols to ensure sample integrity.

The bi-monthly monitoring program will continue, at a minimum, until submittal of the final RFI report (see Section 5.0). Once the arsenic distribution in the intermediate alluvial aquifer has been adequately defined, the residential monitoring program may be revised.

3.3 CONNECTION OF RESIDENTS TO MUNICIPAL WATER SUPPLY

On February 6, 2002, a public meeting was held to discuss the recent RFI groundwater results. During the meeting, Asarco committed to provide hook-ups to the City of East Helena residents who do not have access to City water. In February and March 2002, Asarco met individually with the six residents who live on Gail Street that are not hooked up to the City water supply. Asarco offered to connect the City water supply to each of these homes and abandon their private groundwater well at no cost to the homeowner. Letters will be sent to qualifying residences offering connection to the City water supply and abandonment of their existing groundwater well supply. Until the affected homes are connected to the City of East Helena municipal water supply and the existing groundwater wells have been abandoned, Asarco will continue to conduct sampling of the private residential wells in accordance with Section 3.2 of this work plan.

3.4 ALTERNATIVES FOR ACTION IF CONTAMINANTS REACH RESIDENTIAL WELLS

Results of bimonthly residential monitoring will be reviewed for compliance with water quality standards. Asarco will notify EPA and immediately resample any wells that exceed water quality standards. Per their stipulation (EPA, 2002), EPA will notify the effected residents.

The effected residents and all surrounding residents with wells in active use will be provided with bottled water until City water supply hook-ups are completed. Wells in the affected area will be resampled and Asarco will review the results with EPA to determine appropriate action.

4.0 QUALITY ASSURANCE/QUALITY CONTROL

The quality of data collected during implementation of this IM Work Plan Addendum will be maintained through a program of project-specific quality assurance (QA) and quality control (QC) procedures. Data quality is typically evaluated in terms of the PARCC parameters described below:

- Precision;
- Accuracy;
- Representativeness;
- Completeness; and
- Comparability.

Precision and accuracy are estimated through collection and analysis of field and laboratory quality control samples and comparison with established control limits (Section 4.1). Representativeness, completeness, and comparability of the data will be ensured through adherence to Work Plan guidance and approved Standard Operating Procedures during sample collection and analysis (Section 4.2). Finally, overall data quality will be assessed during the data review and validation process (Section 4.3).

4.1 QUALITY CONTROL SAMPLES

4.1.1 Field QC Samples

Field quality control (QC) samples will be collected as outlined in Tables 3-2 and 3-4, including the following:

- Duplicates -- 1 per 20 samples, with a minimum of 1 per monitoring event
- Splits -- 1 per monitoring event for routine and low-flow events
- Blind Field Standards -- 1 per routine monitoring event
- Deionized Water Blanks -- 1 per 20 samples, with a minimum of 1 per monitoring event

- Equipment Rinsate Blanks -- 1 per 20 samples, with a minimum of 1 per monitoring event

Target control limits for field blanks (both deionized water and equipment rinsate blanks) are no contaminants present above laboratory detection limits. Duplicate and split samples will be collected and results reviewed to assess the precision (reproducibility) of the data. A control limit of $\pm 20\%$ relative percent difference (RPD) for original and duplicate (or split) samples will be used for concentrations greater than 5 times the laboratory detection limit (DL); for concentrations less than 5 times the DL, a control limit of \pm DL will be used.

Relative percent difference is calculated as follows:

$$RPD = \frac{|S - D|}{\frac{(S+D)}{2}} \times 100$$

where RPD = relative percent difference (%)
 S = original sample result; and
 D = duplicate sample result.

Target control limits for blind field standards will be based on manufacturer-specified acceptable ranges.

4.1.2 Laboratory QC

Laboratory quality assurance and quality control will be maintained through adherence to the laboratory's internal quality assurance protocol during analysis. Lab QC sample frequency guidelines are specified in quality assurance (QA) plans for each laboratory.

Laboratory analysis for water samples will include (at a minimum) the following types of QC samples:

- Laboratory preparation blanks;
- Matrix spike duplicates;

- Laboratory duplicates; and
- Laboratory control standards.

Target control limits for laboratory preparation blanks are no contaminants present above laboratory detection limits. Target laboratory duplicate sample control limits for inorganic constituents will be the same as those described in Section 4.1.1 for field duplicates.

Target control limits for matrix (pre-digestion) spike duplicates will be recovery in the range of 75 to 125%. Target control limits for laboratory control standards (LCSs) will be recovery in the range of 80 to 120%.

4.2 REPRESENTATIVENESS, COMPLETENESS, AND COMPARABILITY

Collection of samples that are representative of the sampled media, and are comparable with previously collected data from the site will be ensured through application of standard sampling and analytical procedures. SOPs for collection of field data are listed above in Table 3-4. The majority of these SOPs, with various revisions over time, have been used to guide data collection and field investigation activities within and adjacent to the East Helena facility for more than ten years. All field methods will be fully documented in the project field book, and field and analytical procedures will be subject to the project data quality review process (Section 4.3). The completeness of the data (collection of all measurements specified in the work plan) will also be reviewed during data quality review.

The primary analytical laboratory for the analysis of water samples collected under this Work Plan will be the Asarco Technical Services Center (TSC) Laboratory in Salt Lake City, Utah. The TSC laboratory is certified as an environmental laboratory by the State of Utah and has performed the majority of water quality analyses for the Asarco East Helena project with EPA approval. Laboratory performance is certified regularly by performance audits conducted by the State of Utah and EPA inspectors, and by the use of EPA

protocols. Split samples collected as part of field QC procedures will be submitted to Energy Laboratories in Billings, Montana as an independent check on the primary laboratory's performance. Field water quality parameters will be analyzed by field technicians during sampling.

The laboratory analytical methods to be used for laboratory analysis are listed in Tables 3-2 and 3-4 of this Work Plan. These tables also list detection limit goals where relevant. A copy of the applicable table from the Work Plan will be included with each shipment of samples sent to the laboratory. Requested turnaround times for samples submitted to the laboratory (time from receipt of samples at the laboratory to delivery of sample results) will be two weeks.

In the event that analytical problems arise (e.g., matrix interferences or other problems), the laboratory will be responsible for notifying the project manager. The resolution of analytical problems will be determined cooperatively by the project managers in consultation with the analytical laboratory.

4.3 DATA QUALITY

A review of field and analytical data will be conducted following receipt of laboratory data packages. The data review will focus on the following QA/QC parameters:

- Completeness of sampling and analysis (correct number and types of samples collected, analyzed for the correct parameters);
- Completeness of field and laboratory documentation (information in field notebooks and on laboratory reports is complete and correct relative to the requirements of the work plan);
- Holding times;
- Field QC sample results; and
- Laboratory QC sample results.

Although Contract Laboratory Program (CLP-level) documentation will not be required from the laboratory, data review procedures and application of data qualifiers will follow the general guidance given in *USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 1994). Data qualifiers will be assigned to data which does not meet target quality control criteria (Section 4.1). A summary of the data qualifier codes is shown in Table 4-1.

TABLE 4-1. DATA QUALIFIER CODES AND DEFINITIONS

Code	Definition
J -	The associated numerical value is an estimated quantity because quality control criteria were not met.
U -	Blank contamination. Indicates possible high bias and/or false positive. The associated value is an estimate.
R -	Quality control indicates that the data are unusable (compound may or may not be present). Resampling and/or reanalysis necessary for verification.
A -	Anomalous data. No apparent explanation for discrepancy in data. Applied based on historic results or on comparison with other results for the same sample (not an EPA code).

Summary data validation reports for will be prepared following review of the data received from the laboratory. Typically, separate validation reports will be prepared covering the results of each separate field monitoring event. The validation report will summarize the QA/QC information from the field event and laboratory analysis (including QC sample results), audit information, corrective actions taken (if any), and the overall results of sampling and analytical activities with respect to work plan and QA/QC compliance. The primary focus of the data validation report will be an estimate of the effects any deviations from approved procedures may have on the project objectives or data uses.

5.0 DATA EVALUATION AND REPORTING

5.1 GROUNDWATER CHARACTERIZATION

All data collected in accordance with the program outlined in Section 3.0 will be compiled, evaluated and incorporated into the RCRA Facility Investigation (RFI) report. The RFI report will include all field data collected during the RFI and Interim Measure investigations and will include updated potentiometric maps, stratigraphic cross-sections and isocontour maps showing the horizontal and vertical extent of arsenic in the intermediate aquifer. Relative to this Interim Measures work plan, the RFI report will:

- 1) describe the nature, extent of arsenic in the intermediate alluvial aquifer; and
- 2) evaluate the susceptibility of existing domestic wells to water quality impacts.

5.2 RESIDENTIAL MONITORING

Results of bimonthly monitoring will be submitted to EPA. The results will be attached to the monthly RCRA progress reports and will be included in the RFI report. Copies of the laboratory results will also be sent by Asarco to residents whose wells are being monitored. Asarco will immediately notify EPA by telephone if laboratory results indicate any water quality standards are exceeded. EPA will notify the affected residents in a separate letter to discuss the results and provide further guidance (EPA 2002).

5.3 CITY WATER SUPPLY CONNECTIONS

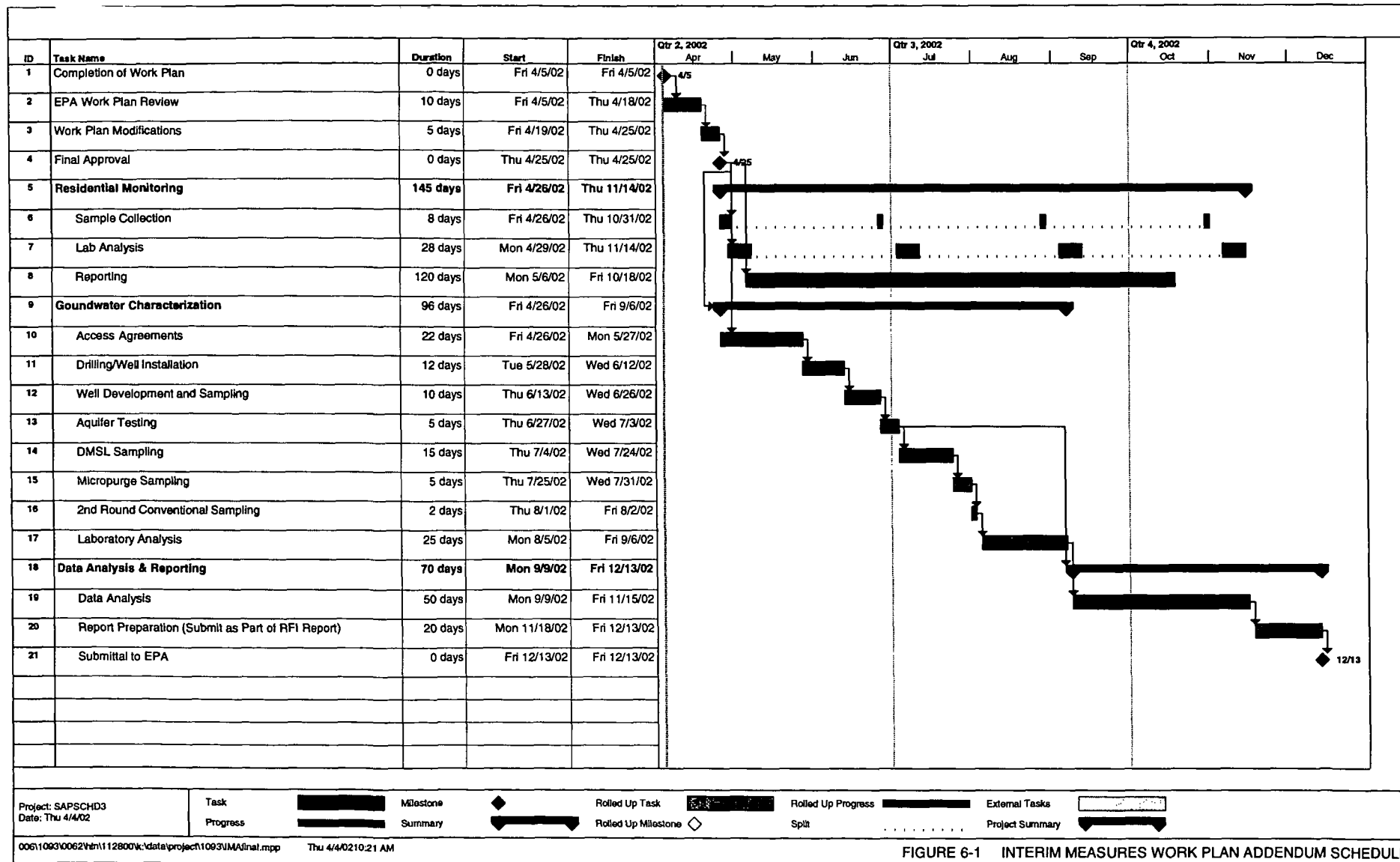
The monthly RCRA progress reports will describe progress on city water connections and abandonments of replaced groundwater supply wells. The information will include names, addresses, dates and status of connection activities.

5.4 ALTERNATE WATER SUPPLY SOURCES

The monthly RCRA progress reports will include information on the status of residence that have been provided alternate water supply source (i.e. bottled water). The information will include names, addresses, dates and status of alternate water supply efforts.

6.0 SCHEDULE

The project schedule is shown on Figure 6-1. It is expected that field investigation efforts will begin in May 2002 following EPA review and approval of the IM Work Plan Addendum. Well installation and a preliminary round of arsenic sampling will be completed within 60 days of Work Plan approval. Additional groundwater characterization work will continue through the summer. Bimonthly sampling of residential wells will begin immediately following Work Plan approval and will continue, at a minimum, until submittal of the RFI report.



7.0 REFERENCES

- Hydrometrics 2000a. RCRA Facility Investigation Work Plan, East Helena Facility, December 2000.
- Hydrometrics 2000b. Supplemental Groundwater Investigation Report, Interim Measures, East Helena Facility, May 2000.
- Hydrometrics, 1999a. Current Conditions Release/Assessment, East Helena Facility, September 1998, Revised January 1999.
- Hydrometrics, 1999b. Interim Measures Work Plan, East Helena Facility, April 1999, Revised July 1999. Includes Volume II, Corrective Action Management Unit Design Report.
- Hydrometrics, 1990. Comprehensive Remedial Investigation/Feasibility Study. Prepared for ASARCO Incorporated. March.
- U.S. District Court for the District of Montana, January 23, 1998. RCRA Consent Decree, East Helena Plant. United States of America, Plaintiff, v. Asarco Incorporated, Defendant. Civil Action No. CV 98-3-H-CCL.
- U.S. Environmental Protection Agency (EPA), 2002. Letter to Douglas McAllister RE: Consent Decree Settling U.S. v. Asarco, Inc. Financial Assurance Requirements and Additional Interim Measures.
- U.S. Environmental Protection Agency (EPA), 1999a. Letter to Jon Nickel, Asarco, RE: Conclusion of CC/RA Phase and Initiation of Interim Measures, Pursuant to Paragraphs VII. 34 and 35 of the Consent Decree (CV98-3-H-CCL).
- U.S. Environmental Protection Agency (EPA), 1994a. RCRA Corrective Action Plan, (CAP), OWSER Directive Number 9902.3-2A.
- U.S. Environmental Protection Agency (EPA), 1994b. Guidance for the Data Quality Objectives Process (EPA QA/G-4, U.S. Environmental Protection Agency, Washington, D.C. EPA/600/R-96-005 September 1994.
- Zazzali, Susan, 2002. U.S. Environmental Protection Agency letter to Dougals McAllister dated January 30, 2002.

APPENDIX A

STANDARD OPERATING PROCEDURES

STANDARD OPERATING PROCEDURE

PRESERVATION AND STORAGE OF INORGANIC WATER SAMPLES® HF-SOP-3

1.0 PURPOSE

An important factor in obtaining representative water quality data is the preservation and storage of samples. Preservation is designed to:

1. Retard biological activity;
2. Retard chemical reactions; and
3. Reduce volatility of constituents.

Preservation generally includes chemical additives, pH control, refrigeration, proper container materials, and immediate field filtration for dissolved constituents.

2.0 EQUIPMENT

Table 1 (attached) lists recommended preservatives, containers and holding times for various parameters. Be sure to assemble all the required containers, preservatives, and filters, as required, before leaving for the field.

3.0 PROCEDURE

In all cases where dissolved constituents are to be measured, the sample will be field-filtered through a 0.45 micron filter prior to addition of a preservative. Samples will be preserved according to guidelines presented in **Table 1**, and will remain refrigerated or in coolers with ice until analysis.

Complete sampling form for groundwater or surface water (**HF-FORM-430**).

4.0 REFERENCES

U.S. EPA, 1983. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, 3rd Edition.

TABLE 1. REQUIRED CONTAINERS, PRESERVATION TECHNIQUES AND HOLDING TIMES

<u>Parameters</u>	<u>Container¹</u>	<u>Preservative</u>	<u>Maximum Holding Time</u>
Specific Electrical Conductivity	T, P, G	Field determined	None
Total Dissolved Solids (TDS)	P, G	Cool, 4°C	7 Days
Total Suspended Solids (TSS)	P, G	Cool, 4°C	7 Days
pH	T, P, G	Field determined	None
Dissolved Oxygen (DO)	G bottle and top	None required	Analyze immediately
Temperature	P, G	None required	Analyze immediately
Eh	P, G	None required	Analyze immediately
Alkalinity	P, G	Cool, 4°C	14 days
Calcium (Ca)	P, G	HNO ₃ to pH <2	6 months
Magnesium (Mg)	P, G	HNO ₃ to pH <2	6 months
Sodium (Na)	P, G	HNO ₃ to pH <2	6 months
Potassium (K)	P, G	HNO ₃ to pH <2	6 months
Bicarbonate (HCO ₃)	P, G	Cool, 4°C	14 days
Carbonate (CO ₃)	P, G	Cool, 4°C	14 days

¹ T = Teflon; P = Polyethylene; G = Glass

TABLE 1 (Continued). REQUIRED CONTAINERS, PRESERVATION TECHNIQUES AND HOLDING TIMES

<u>Parameters</u>	<u>Container¹</u>	<u>Preservative</u>	<u>Maximum Holding Time</u>
Sulfate (SO ₄)	T, P, G	Cool, 4°C	28 days
Chloride (Cl)	T, P, G	Cool, 4°C	28 days
Silica (Si)	P	Cool, 4°C	28 days
Fluoride (F)	T, P	HNO ₃ to pH <2	28 days
<u>METALS*</u>			
Aluminum (Al)	T, P	HNO ₃ to pH <2	6 months
Antimony (Sb)	T, P	HNO ₃ to pH <2	6 months
Arsenic (As)	T, P	HNO ₃ to pH <2	6 months
Barium (Ba)	T, P	HNO ₃ to pH <2	6 months
Beryllium (Be)	T, P	HNO ₃ to pH <2	6 months
Cadmium (Cd)	T, P	HNO ₃ to pH <2	6 months
Chromium (Cr)	T, P	HNO ₃ to pH <2	6 months
Cobalt (Co)	T, P	HNO ₃ to pH <2	6 months
Copper (Cu)	T, P	HNO ₃ to pH <2	6 months
Iron (Fe)	T, P	HNO ₃ to pH <2	6 months
Lead (Pb)	T, P	HNO ₃ to pH <2	6 months
Manganese (Mn)	T, P	HNO ₃ to pH <2	6 months

¹ T = Teflon; P = Polyethylene; G = Glass

* Dissolved metals are filtered on site with 0.45 micron filter. Total metals are not filtered.

**TABLE 1 (Continued). REQUIRED CONTAINERS, PRESERVATION
TECHNIQUES AND HOLDING TIMES**

<u>Parameters</u>	<u>Container¹</u>	<u>Preservative</u>	<u>Maximum Holding Time</u>
Mercury (Hg)	T, P	HNO ₃ to pH <2	28 days
Nickel (Ni)	T, P	HNO ₃ to pH <2	6 months
Selenium (Se)	T, P	HNO ₃ to pH <2	6 months
Silver (Ag)	T, P	HNO ₃ to pH <2	6 months (in dark place)
Tin (Sn)	T, P	HNO ₃ to pH <2	6 months
Thallium (Th)	T, P	HNO ₃ to pH <2	6 months
Vanadium (V)	T, P	HNO ₃ to pH <2	6 months
Zinc (Zn)	T, P	HNO ₃ to pH <2	6 months

PHOSPHORUS (P)

Orthophosphate (PO ₄), Dissolved	P, G	Filter on site, Cool, 4°C	48 hours
Orthophosphate, Total	P, G	Cool, 4°C	48 hours
Hydrolyzable	P, G	Cool, 4°C H ₂ SO ₄ to pH <2	28 days
Total	P, G	Cool, 4°C H ₂ SO ₄ to pH <2	28 days
Total, Dissolved	P, G	Filter on site Cool, 4°C H ₂ SO ₄ to pH <2	24 hours

¹ T = Teflon; P = Polyethylene; G = Glass

TABLE 1 (Continued). REQUIRED CONTAINERS, PRESERVATION TECHNIQUES AND HOLDING TIMES

<u>Parameters</u>	<u>Container¹</u>	<u>Preservative</u>	<u>Maximum Holding Time</u>
<u>NUTRIENTS</u>			
Ammonia	P, G	Cool, 4°C H ₂ SO ₄ to pH <2	28 days
Kjeldahl, Total	P, G	Cool, 4°C H ₂ SO ₄ to pH <2	28 days
Nitrate plus Nitrite	P, G	Cool, 4°C H ₂ SO ₄ to pH <2	28 days
Nitrate (NO ₃)	T, P, G	Cool, 4°C or Cool, 4°C H ₂ SO ₄ to pH <2	48 hours 14 days
Nitrite (NO ₂)	P, G	Cool, 4°C	48 hours

¹ T = Teflon; P = Polyethylene; G = Glass

STANDARD OPERATING PROCEDURE

PACKING AND SHIPPING SAMPLES® HF-SOP-4

1.0 PURPOSE

This procedure is to be followed when packing and shipping water or soil samples to the laboratory by commercial carrier. The Chain-of-Custody standard operating procedure (HF-SOP-5) also must be followed if required in the project plan.

2.0 PROCEDURE

- 2.1 All samples must be labeled and labels filled out in waterproof ink. The label can be Hydrometrics' standard shipping label or may be a project-specific label. Sample labeling procedures are detailed in **HF-SOP-29** (Labeling and Documentation of Samples).
- 2.2 All samples are placed in the shipping container - normally a metal or plastic cooler.
- 2.3 Packing:
 - 2.3.1 Sample containers are typically placed in a cooler. Other commercially available insulated containers may be used. The project manager should determine that the containers are appropriate to the type of sample being shipped.
 - 2.3.2 If trip blanks are required, typical for organics sampling, be sure one is present for each and every shipping container.
 - 2.3.3 If an ice pack is used, place the ice pack in the cooler or cooler lid as needed. Fill space with bubble mat wrap or packing material. If necessary, place bubble wrap on top of samples. Sufficient packing material should be used to prevent sample containers from contacting each other during transport.
 - 2.3.4 If custody seals are required, they will be placed on at least two places connecting the cooler container lid to the cooler.
 - 2.3.5 Coolers are then wrapped with nylon strapping tape. Two full rotations of tape will be placed at least two places on the cooler.
- 2.4 Packing and shipping procedures for Superfund facilities should follow guidelines outlined in the EPA document "A Compendium of Superfund Field Operating Methods".

3.0 SHIPPING

Samples can be sent by commercial air carrier, overnight express, Federal Express or other means. The allowable holding time and often the ability to keep samples cold are important considerations. Copies of all shipment records must be kept in the project files.

Each sample container will be marked with:

- Sampling organization name, address and telephone number;
- Laboratory name, address and telephone number; and
- Ship samples via courier following any applicable DOT requirements. The project manager should determine if there are any special shipping considerations.

3.1 Documents

Each shipping container will contain a description of samples enclosed, date of collection and date of shipment, either a cover letter or a Request for Analytical Services, and/or a Chain-of-Custody form. See Labeling and Documentation of Samples (**HF-SOP-29**).

For Chain-of-Custody shipments complete a Chain-of-Custody form (see Chain-of-Custody Standard Operating Procedure **HF-SOP-5**).

- Sign the form.
- Place two copies in zip-lock bag in sample container.
- Keep one signed copy in project file.

Signing of the Chain-of-Custody form (record) relinquishes custody of the samples. Relinquishing custody should only occur when directly shipping to the analytical laboratory.

4.0 RELATED REFERENCES

HF-SOP-5 Chain-of Custody Procedure

HF-SOP-29 Labeling and Documentation of Samples

U.S. EPA, 1982. Handbook for Sampling and Sample Preservation of Water and Wastewater. EPA-600/4-82-029.

U.S. EPA, 1987. A Compendium of Superfund Field Operations Methods PB88-181557.

STANDARD OPERATING PROCEDURE

CHAIN-OF CUSTODY® HF-SOP-5

1.0 PURPOSE

The purpose of this procedure is to maintain a chain-of-custody for samples. All soil and water samples collected and sent to the laboratory for analysis will be documented using standard chain-of-custody procedures.

2.0 CUSTODY PROCEDURE

Samples will be collected at established project sampling sites using Standard Operating Procedures (SOP). Sampling activities will be recorded in the samplers daily log book and the appropriate collection form(s) completed (see appropriate sampling SOP). Each sample container will be identified by labeling. Labels are attached to sample bottles and are protected with clear label tape to prevent abrasion of labeling information and to guard against failure of label adhesive.

2.1 Sample Identification

Each sample bottle should be labeled with the following information:

- Site;
- Sample Number;
- Person taking the sample;
- Date and time of collection;
- Sample matrix (water, soil, oil, etc.);
- Basis (total or dissolved);
- Preservation; and
- Analyses to be performed.

Labels will be written in waterproof ink.

Use of pre-printed, self-adhesive labels, if available, is preferred.

All samples must be traceable from the time the samples are collected until they are received by the analytical laboratory. The laboratory is then responsible for custody during processing and analysis.

A sample is under custody if:

- It is in your possession;
- It is in your view, after being in your possession;
- It was in your possession and then you locked it up to prevent tampering; or
- It was in your possession and then you placed it in a designated secure area.

2.2 Custody Records

Each sample is identified on a Chain-of-Custody Form(s) (**HF-FORM-001**) by its sample number, date and time of collection, and analysis requested.

Documents will consist of:

- Sample collection records;
- Chain-of-Custody form(s) (**HF-FORM-001**);
- Analytical Parameter List(s) including analytical methods and detection limits if not on the Chain-of-Custody form;
- Shipping receipt(s); and
- Purchase Order(s).

3.0 CUSTODY TRANSFER AND SHIPMENT

All samples will be accompanied by **Chain - of - Custody** record (**HF-FORM-001**). The following procedures will be followed:

- When transferring the possession of samples, the individual(s) relinquishing and receiving will sign, date and note the time on the record. This record documents sample custody transfer from the sampler to the laboratory.

- Samples will be packaged properly for shipment and dispatched to the appropriate laboratory for analysis, with a separate custody record accompanying each shipment. Shipping containers will be sealed for shipment to the laboratory. The method of shipment, courier name(s) and other pertinent information are entered in the "Remarks" box.
- All shipments will be accompanied by the **Chain - of - Custody Record (HF-FORM-001)** identifying its contents. The original record will accompany the shipment and a copy will be retained in the project file.
- Analytical parameters requested must be noted on the Chain-of-Custody Record, or an attached analytical parameters list accompanying the Chain-of-Custody Record. If not attached to the Chain-of-Custody, an Analytical Parameter List including analytical methods and detection limits must be included with each shipment and should specify methods of analysis required for each parameter.
- All shipping receipts (next day air waybills, freight bills, post office receipts, bills of lading, etc.) purchase orders, and sample collection records will be retained in the project file.


4.0 CUSTODY SEALS

When samples are shipped to the laboratory, they must be placed in containers sealed with custody seals. A typical custody seal is shown in **Figure 1**. Some custody seals are serially numbered. Other custody seals are unnumbered seals or evidence tape.

Two seals must be placed on each shipping container (cooler), one at the front and one at the back as shown in **Figure 1**. Clear tape should be placed over seals to ensure that seals are not accidentally broken during shipment.

5.0 RELATED REFERENCES

HF-FORM-001 - Chain-of-Custody Record (3-part NCR form)

	UNITED STATES ENVIRONMENTAL PROTECTION AGENCY OFFICIAL SAMPLE SEAL	SAMPLE NO. _____	DATE _____
		SIGNATURE _____	
		PRINT NAME AND TITLE (<i>Inspector, Analyst or Technician</i>) _____	
		SEAL ORDER BY _____	DATE _____
		EPA FORM 7600-2 (17-78)	

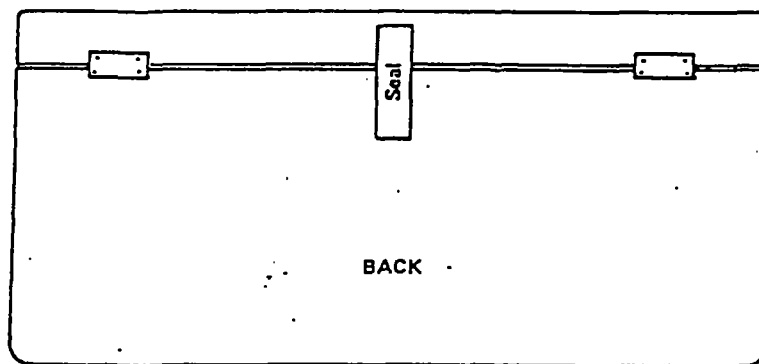
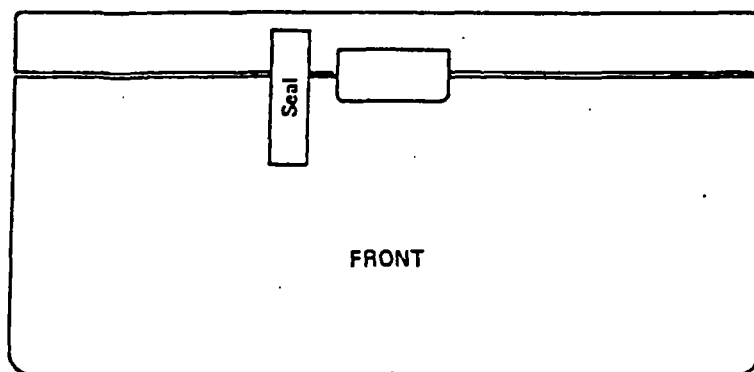


Figure 1. Proper Placement of Custody Seals

STANDARD OPERATING PROCEDURE**DECONTAMINATION OF SAMPLING EQUIPMENT[®]**
HF-SOP-7**1.0 PURPOSE**

Unless entirely disposable sampling equipment is used, cross-contamination can occur and all sampling equipment must be decontaminated between sampling points. The following types of equipment will require decontamination:

1. Bailers used to obtain samples from wells;
2. Containers used to composite or contain samples;
3. Soil piston sampler;
4. Water filter apparatus (0.45 micron);
5. Soil coring devices; and
6. Drilling rig and/or backhoe.

2.0 EQUIPMENT

One or more of the items below is required. Check procedures that follow.

Tap water
Detergent
High Pressure Washer

Plastic gloves
Deionized (DI) Water
Organic solvent (preferably
hexane or methanol), certified
ACS Grade or better

Detergent
Buckets
Brushes

3.0 PROCEDURES

Effective decontamination of sampling equipment for sampling inorganics can be achieved by using the following three step process:

1. Wash equipment in warm water and detergent, scrubbing with brushes as necessary to remove visible contaminants;
2. Rinse equipment thoroughly with clean tap water; and
3. Rinse equipment thoroughly with DI (deionized) water.

When sampling for various organic parameters which leave heavy residues on sampling equipment, decontamination may require additional steps:

4. Solvent rinse (preferably hexane or methanol, certified ACS Grade or better); and
5. DI water rinse.

Deionized water used during sampling equipment decontamination should be obtained from a source with documented capability to produce contaminant-free water. The source of DI water used (both production source and individual carboy) and any available measurements such as specific conductivity should be recorded in the field notebook. At least 50 mL of DI water should be run through the DI carboy spout prior to using DI water for decontamination or blank sample purposes. The volume of DI water used in the final equipment rinse should be minimized. Judicious use of DI water during equipment decontamination in the field will help prevent field shortages, which can lead to "emergency" situations and the use of DI water from unfamiliar and untested sources.

Specific decontamination procedures used should be recorded in field notebooks. Special procedures (i.e., dilute acid rinses, alternate solvent rinses) may be required for some projects. Any departures from the basic protocol given above for inorganics or organics should also be noted.

The subsections below suggest specific procedures relevant to equipment which may require frequent decontamination.

3.1 BAILERS

Bailers normally will be stainless steel, teflon or PVC plastic (**NOTE: PVC is not to be used when organics are of concern**). A bailer can be used exclusively on one monitoring well (dedicated bailer) or used on multiple holes.

If dedicated bailers are used, they will be rinsed with municipal tap water, then rinsed with DI (deionized) water. The bailers then will be stored in capped PVC containers in Hydrometrics' storage area.

Bailers that are used in more than one well will be decontaminated by rinsing between wells. All bailers will be rinsed a minimum of three times with the water to be sampled before the sample is taken.

Ropes or cords used for bailers will be polypropylene or nylon and will be changed after each use on an individual hole if they become wet or are suspected of causing cross-contamination. If cross-contamination is suspected for the ropes or cords, then they will be discarded after use. If cross-contamination from ropes or cords appears to not be a concern, the ropes or cords will be rinsed with tap water, rinsed in DI water and allowed to dry prior to the next usage.

3.2 CONTAINERS

Commonly, a container will be used to composite or hold water obtained by bailing wells. Between samples, these containers must be decontaminated. The container also will be rinsed a minimum of three times with water to be sampled.

3.3 SOIL PISTON SAMPLER

The soil piston sampler will be decontaminated between sample sites by washing in warm water and detergent followed by rinses in tap water and DI water.

3.4 WATER FILTER

If a pressure water filter apparatus is used to filter water samples through 0.45 micron membranes, this filter apparatus must be decontaminated after each use. This will involve rinsing three times with DI water and discarding the filter. The filter apparatus is then rinsed three times with the water to be sampled prior to taking the sample. Additionally, a volume of sample water is flushed through the new filter before the actual sample is taken (see **HF-SOP-73, Filtration of Water Samples**).

3.5 SOIL CORING DEVICES

Soil samples may be obtained from drill holes by use of coring devices. Split spoons or Shelby tubes can be used. These devices will be decontaminated by thoroughly washing between each sampling depth and sampling sites. Washing will include warm water and detergent followed by a rinse with tap water and DI water.

3.6 DRILLING RIG

Cross-contamination may occur from the drilling rig. The drilling rods and drilling bits will be washed with tap water between holes and, if necessary, they will be washed with warm water and detergent to remove all dirt or other potentially contaminated material.

A pressurized washer shall be used that is capable of producing 1500 psi at a temperature of 120°F. The detergent wash shall be followed by a warm water rinse. This procedure is applicable for both **ORGANIC** and **INORGANIC** samples.

3.7 BACKHOE

Cross-contamination may occur from the backhoe. Therefore, the bucket and boom shall be washed with a pressurized washer capable of producing at least 1500 psi at a temperature of 120°F. The backhoe shall be washed with detergent water and then rinsed with municipal tap water. This procedure is applicable for both **ORGANIC** and **INORGANIC** samples.

4.0 RINSATE BLANK COLLECTION

Equipment used in collection of water samples will require testing to assure that decontamination procedures are effective. This will be accomplished by rinsing of the sampling equipment with deionized water and measurement of the concentration of parameters of interest in this "blank sample". Sufficient blanks will be collected to ensure there is no cross-contamination caused by the sampling device. Details of rinsate blank collection procedures are contained in **HS-SOP-13, Rinsate Blank Collection**.

A frequency of one such rinsate blank per 20 samples collected, with a minimum of one blank, is to be generally employed (refer to the project plan).

5.0 ASSOCIATED REFERENCES

HF-SOP-73 Filtration of Water Samples

HS-SOP-13 Rinsate Blank Collection

STANDARD OPERATING PROCEDURE

LOGGING OF MONITORING WELLS

GEOLOGICAL CONDITIONS, CONSTRUCTION AND DEVELOPMENT®

HF-SOP-9

1.0 PURPOSE

All project monitoring wells will be logged by an experienced professional hydrogeologist or geologist from Hydrometrics. The objective of logging is to document subsurface geology, hole drilling conditions and borehole completion details. The purpose of this monitoring well SOP is to provide a) durable and reliable monitoring well construction, 2) allow the extraction of representative groundwater samples, 3) allow efficient and complete hydrogeological characterization, and 4) to prevent the vertical migration of groundwater or surface water between aquifers via the well.

2.0 PROCEDURE

The following procedures will be used for logging monitoring wells. This procedure is applicable to boreholes drilled with rotary, cable tool, auger, downhole hammer, Geoprobe or other drilling methods.

- 1) An experienced and properly licensed drilling contractor will be used. The planned drilling and well construction procedures will be discussed and reviewed with the drilling contractor who will read and sign a completed contract prior to commencement of drilling.
- 2) All drilling and testing will be directly supervised by an experienced professional hydrogeologist or geologist, preferably one who is also a licensed monitor well constructor (in states where applicable). Drilling and test results will be recorded on Hydrometrics Well Log Form (**HF-FORM 702**; attached) or an equivalent form. The location of the well will be described with any pertinent geological or geographic features.
- 3) Drill cuttings will be examined continuously as drilling progresses. Borehole sampling methods may also include split spoon, ring, denneison, shelly, or california tube, and coring. Borehole descriptions should be recorded at a minimum of 5 foot intervals, and will include information on lithologic percentages, color, mineralogy, grain size, sorting, grading, texture, angularity, cementation, induration, porosity, moisture, competency, fracturing, and other pertinent characteristics. Other pertinent characteristics include permeability and presence or absence of anthropogenic impacts. Refer to ASTM Guide D2488-93 "Standard Practice or Description and Identification of Soils".

- 4) Drilling conditions will be recorded, including depth to water, volume of water encountered, rate of penetration, fractured horizons, hole heaving or caving, use and type of any drilling fluids or additives. If water is used during drilling, the source and quantity of water used shall be recorded.
- 5) Well construction details to be recorded include boring depth and diameter; well casing size, type, and diameter, depth and length of casing including screened or perforated sections; screen slot size; depth, type and emplacement method of annulus backfill including sand or gravel packs, seals, packers and surface seals; protective casing or housing; dedicated sampling system (if applicable), measuring point elevation and well head protection. All casing lengths and depths of sand or gravel packs will be measured. The final well depth will be measured and compared to measured casing lengths. All measurements should be to the nearest 0.1 feet.
- 6) Well construction must conform to the applicable regulations governing monitoring well installation at a particular site, in a particular state or both. For example, in Montana a licensed monitoring well constructor must be physically present at the site throughout construction of the monitoring well. This individual must submit a monitoring well report to the Montana Board of Water Well Contractors and the owners of the well within 60 days of completing the well, in addition to other guidelines.
- 7) See Figure 1 for typical monitoring well construction which may vary based on site-specific conditions.
- 8) Well development and testing activities will be documented, including type and duration of development, response of the well to development, and turbidity and sand content of water removed from the well. If an external water source is used for well development purposes, its source and quality must be noted on Hydrometrics' Well Development Log Form (**HF-FORM-435**; attached).

The objective of monitoring well development is to: 1) enhance the flow of groundwater from the formation into the well, 2) minimize the amount of sediment in water samples collected from the well, and 3) restore as best as possible the subsurface area adjacent to the well that has been altered by drilling activities so that a representative sample of water as it exists in the formation can be obtained from the well, 4) minimize any hydraulic gradients from the well bore to the media being monitored.

The type and length of development should be based on consideration of the following three factors: 1) the type of geologic material, 2) monitoring well completion design, and 3) drilling method employed during borehole construction, and 4) the amount and quality of water added to the borehole during drilling. Generally a well is developed until the discharge runs clear. A turbidity specification (in NTUs) can also be used.

Monitoring well development should attempt to remove fine particulate matter (silts, clays, sand) from the geologic formation near the well intake. Therefore, development should encourage the movement of particulates into the well. The particulates can then be removed by bailing or pumping. Development should also remove any fluids that were added to the borehole during drilling. If drilling fluids were added to the borehole, a minimum of 2-3 times the volume added should be removed from the well during development and field parameters (pH, SC) should be monitored during development. Development should continue until these parameters have stabilized.

The most suitable methods for monitoring well development include: 1) bailing, 2) surge-block surging, 3) pumping, overpumping, backwashing, or 4) a combination of these methods. Generally, methods that should be avoided for development of monitoring wells include: flushing, jetting, and air surging. Well development techniques, where possible, should avoid the use of introduced fluids and air into the monitored zone during development.

- 9) Generally monitoring wells should not be sampled for water quality until at least one week after a well has been developed to allow the aquifer to equilibrate and a representative water sample can be collected.

3.0 ASSOCIATED REFERENCE

American Society for Testing and Materials (ASTM), 1993. Standard Practice for Description and Identification of Soils (Visual- Manual Procedure) ASTM Designation D2488-93.

National Water Well Association, 1986. RCRA Groundwater Monitoring Technical Enforcement Guidance Document (TEGD). September 1986.

**STANDARD OPERATING PROCEDURE
FIELD LOG COVER FORM
(HF-FORM-702)**

HYDROMETRICS, INC. Field Log Cover Form		Well/Boring Name: _____	
Project Information	Construction Information		
Name _____	Well Surf. Detail <input type="checkbox"/> stickup <input type="checkbox"/> flush mount <input type="checkbox"/> stand pipe		
Client _____	Surface Casing Ht. _____		
Property Owner _____	Riser Height _____		
Project Number _____	Well Materials _____		
	Well Interval _____		
Point Identifying Information	Surf Casing Desc. _____		
Point ID _____	Surf Casing Int. _____		
County _____	Screen Desc. _____		
State _____	Screen Int. _____		
Legal Desc. _____	Filter Pack Desc. _____		
Desc. Location _____	Filter Pack Int. _____		
Samp. # Prefix _____	Annular Seal Desc. _____		
Log Title _____	Annular Seal Int. _____		
Hole Depth _____	Surf Seal Desc. _____		
Elevation (GS) _____	Surf Seal Int. _____		
Elevation (MP) _____	Development Desc. _____		
Northing _____	Development Int. _____		
Easting _____	Water Samples Desc. _____		
	Water Samples Int. _____		
Drilling Information	Soil Samples Desc. _____		
Date Started _____	Soil Samples Int. _____		
Date Finished _____	Depth Water Encountered _____		
Recorded By _____	Remarks _____		
Drilling Company _____			
Driller _____			
Drilling Method _____			
Drilling Fluids _____			
Purpose _____			
Target Aquifer _____			
Hole Dia. _____			
Measuring Information	Well Diagram Information		
Datum _____			
Static Water Level _____			
Static Water Date _____			
MP Description _____			
MP Height _____			
Signature _____			

	Top	Bot.	Graphic	Description
Surface Seal		R	CMNT11	
Annular Seal		R	BENT11	
		R		
Filter Pack		R	FILT11	
		R		
Screen		L	SLOT11	
		L		
Bottom Cap			PCAP11	(None Needed)
Backfill		R	SLUF11	

HYDROMETRICS, INC.

Photos: Y N

Well Name:

Well Log Field Form: Graphical Logs

Personnel:

Page ____ of ____

Graphical Description (optional)

Geological Log

Depth	Geology	Hatch Pattern	Well Completion	Water Info.	Top Depth	Bot. Depth	Hatching	Material Name	Unit Name
					Description				
					Description				
					Description				
					Description				
					Description				

CONCRETE PAD
SHOULD EXTEND BELOW
MAXIMUM FROST LINE
TO MINIMIZE HEAVING

STEEL SURFACE CASING WITH PROTECTIVE
STEEL COVER AND LOCK
TOP CAP

GROUND SURFACE

SEALING MATERIAL SHALL CONSIST OF:
NEAT CEMENT GROUT, BENTONITE CLAY
GROUT, CUTTINGS SLURRY GROUT OR
OR COMPACTED CLAY CUTTINGS

MINIMUM OF 1½ INCHES BETWEEN
WELL AND BOREHOLE ANNULUS

MINIMUM 2 INCH I.D. NSF APPROVED
SCH. 40 PVC WITH FLUSH JOINT
THREADED COUPLINGS

¼" CLEARANCE

CENTERING GUIDES FOR WELLS > 20
FEET DEEP

2 FEET MINIMUM OF BENTONITE PELLETS

SAND PACK PLACED AS TEMPORARY
CASING IS PULLED BACK MINIMUM 2
FEET ABOVE SLOTTED SECTION

BOREHOLE
ANNULUS

FACTORY SLOTTED 2 INCH MINIMUM I.D.
SCHEDULE 40 PVC SIZED TO FORMATION
AND/OR FILTER PACK MATERIAL

BOTTOM CAP

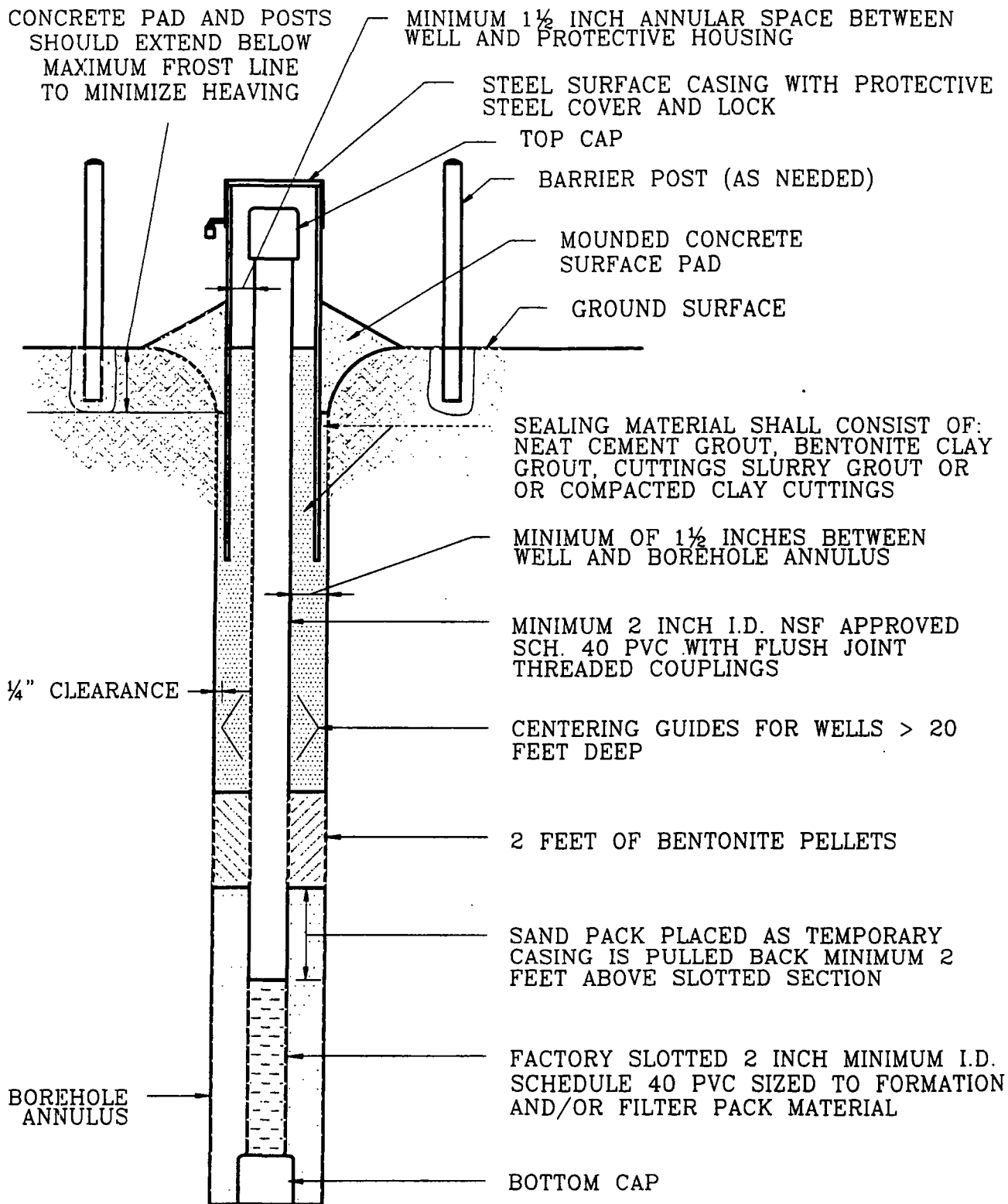
TYPICAL MONITORING WELL CONSTRUCTION
NOT TO SCALE

HF-SOP-9

TYPICAL FLUSH MOUNT
MONITORING WELL CONSTRUCTION

FIGURE

1



TYPICAL MONITORING WELL CONSTRUCTION
NOT TO SCALE

HF-SOP-9

TYPICAL SHALLOW
MONITORING WELL CONSTRUCTION

FIGURE

1

STANDARD OPERATING PROCEDURE FORM

WELL DEVELOPMENT LOG[®]
HF-FORM-435

WELL No. _____

WELL DATA

Project Name _____ State _____ County _____
Location: T _____ R _____ Sec. _____ Tract _____
Well _____ Location _____ (Narrative _____ Description)
Well Depth (ft) _____ Dia (in) _____ Perf. Interval _____
Static Water Level _____ [ABOVE BELOW MP]
MP Desc. _____ Meas Date & Time _____
Aquifer _____

DEVELOPMENT DATA

Date _____ Date Started _____ Date Finished _____
Tot Development Time _____ Est. Yield at Start _____ Est. Yield at End _____
Equipment: BAILER SAND PUMP COMPRESSOR SURGE BLOCK DRILLING
OTHER _____
Desc. of Equipment _____
Dev. Additives Used _____
Desc. of Packer & Surface Seals _____
Water Color & Turbidity: At Start _____ At End _____
Static Water Level After Development:
Time _____ SWL _____ Trend _____
Operator _____
Water Quality Samples Taken? YES NO

REMARKS

STANDARD OPERATING PROCEDURE

WATER LEVEL MEASUREMENT WITH AN ELECTRIC PROBE®

HF-SOP-10

1.0 PURPOSE

This procedure applies to all water level measurements obtained using an electric probe. Normally, this procedure is used for measurement of water levels in wells. All electrical probes used, such as an Olympic Well Probe or Solinst, must have permanent depth markers placed at a minimum of every five feet on the probe wire or must have a direct reading tape.

2.0 EQUIPMENT

- Electronic probe;
- Water level measurement form (**HF-FORM-430**, Water Sampling Form);
- Field notebook; and
- Probe calibration data.

3.0 PROCEDURE

The water level is obtained by lowering the probe until contact is made between the probe tip and the water surface. The contact point is carefully checked by a slight lowering and raising of the probe and simultaneously observing the needle deflection, buzzer or light on the meter. For accurate measurements, the wire line must be straight as the probe is lowered. This is particularly important for the first few feet of line. Water depth is determined by direct reading of the probe wire or by measurement of the wire to the center of the nearest large marker and addition or subtraction from the marker value.

Water level measurements are referenced to the measuring point (MP). Normally, the MP is the top of a well casing but may be some other point. The MP used must be described. The north edge of the casing is usually marked or notched and all water level measurements are referred to this marked point.

3.1 CALIBRATION

All electric probes must be periodically calibrated. Normally, calibration is once or twice per year but, if the probe has been rebuilt, stretched, or replaced, it also must be recalibrated. For

recalibration, the electrical line is laid out on a flat surface and stretched to approximate its normal hanging weight. A steel tape graduated in 0.01 foot increments is used to determine probe accuracy. Additionally, the probe must be placed in wells with differing water levels and water depth measured and compared with a steel tape. A calibration record with correction factor is developed and placed in the equipment calibration file. This calibration record is used in the field to correct probe readings.

3.2 MEASUREMENT ACCURACY

All water levels and calibrations are normally measured to the nearest 0.01 foot. Probe data are considered accurate to 0.05 feet under good measurement and calibration conditions and to 0.10 feet under normal conditions. For deep or difficult conditions, accuracy may be less than 0.10 feet.

3.3 PROBE DECONTAMINATION

For projects where cross-contamination of wells may be a problem, the well probe and line must be decontaminated between measurement sites. This is particularly important when measuring wells containing substances such as PAH (polyaromatic hydrocarbons), pesticides, petroleum products and some metals.

Decontamination must include cleaning the probe and wire line. Most organics can be removed by wiping the line, then using detergent in water followed by acetone or methanol, followed by rinsing with DI (deionized) water.

Many inorganics can be removed by wiping the wire line and rinsing the probe in DI water. Specific attention must be paid to any sediment, rust or dirt on the wire line.

STANDARD OPERATING PROCEDURE

SAMPLING MONITORING WELLS FOR INORGANIC PARAMETERS®

HF-SOP-11

1.0 PURPOSE

This procedure describes the methods to be used in collection of groundwater samples from wells. The procedure is designed for wells where inorganic constituents are of primary concern. Methods presented in this SOP are based on recent USGS guidance (USGS, 1999).

2.0 EQUIPMENT

Bailers, submersible pumps, sample containers and water level electric probe. Other sampling equipment may be required for specific tasks. Other general equipment may include:

- Distilled or deionized water;
- Sampling sheets;
- Samplers notebook;
- Coolers;
- Preservatives;
- 0.45 µm filter apparatus with inert filters;
- Chemical-free paper towels;
- Properly cleaned sample containers of an appropriate volume; and
- Stopwatch or watch with second hand.

3.0 PROCEDURE

- A. Unlock and open well.
- B. Obtain water level measurement (see water level **HF-SOP-10**). If total well depth is unknown, measure total depth by sounding well. NOTE: electric water level probes are typically not recommended for sounding wells; instead, use a weighted measuring tape or other equipment.
- C. Calculate well volume (see calculation on HF-FORM-430) as $[(H) \times (D)^2] / 25$, where H = height of water column (feet), and D = well diameter (inches).

D. Purge well using an appropriate device (bailer, pump, etc.). Standard procedure involves removal of a minimum of three well volumes of water while monitoring field measurements and water level over time. In addition, purge volume should be adequate to remove water from the well annulus (filter pack). Record all pertinent purging information in field notebook and/or on field sampling forms, including:

- Purge method, rate, and total volume;
- Field parameter measurements;
- Water level changes (drawdown/recovery);
- Location of pump intake; and
- Other information.

The USGS (1999) recommends pumping or otherwise purging at a rate that does not significantly lower the water level. Toward the end of purging, a minimum of five sets of field parameters should be collected at regular intervals while pumping at the rate to be used for sampling. Use of a flow cell for field parameter monitoring is recommended. Field parameters are considered "stable" when the variability between five sequential measurements is as follows:

<u>Parameter</u>	<u>Stability Criteria</u>
pH	± 0.1
Temperature ($^{\circ}\text{C}$)	± 0.2
SC ($\mu\text{mhos/cm}$)	$\pm 5\%$ ($\text{SC} \leq 100$) or $\pm 3\%$ ($\text{SC} > 100$)
Dissolved oxygen (mg/L)	± 0.3
Turbidity (NTU)	$\pm 10\%$ ($\text{NTU} < 100$)

Modifications of the standard purge procedure are allowable if site conditions, the project work plan, or study objectives dictate such modifications. At a minimum, sufficient water must be removed to rinse equipment and sample bottles, and field measurements must be monitored prior to sampling. Low-flow (micropurge) techniques are discussed in a separate procedure (HF-SOP-105).

- E. Samples are collected after a sufficient purge volume is withdrawn and/or field parameters have stabilized and final field measurements have been collected. Bottles are filled directly from discharge from the well or from another clean container. Considerable care should be taken to minimize entrainment of air, particularly if bailers are used for sampling.
- F. Preserve and store samples as appropriate for the intended laboratory analysis. Collect final water level measurements if desired to determine water level recovery following purging.

4.0 DECONTAMINATION

If cross contamination of sampled wells is a potential problem, the following procedure should be followed:

- A. Design sampling to proceed from the best quality water to the poorest quality water; and
- B. Rinse the pumping apparatus or bailer between holes if well yields are too low to supply sufficient water to purge the pump, water hose or bailer.

If contamination is a problem, dedicated pumps or bailers should be used to ensure the samples are representative of site conditions (see Decontamination of Sampling Equipment **HF-SOP-7**).

5.0 ASSOCIATED DOCUMENTS

- A. Decontamination of Sampling Equipment (**HF-SOP-7**)
- B. Water Level Measurement with an Electric Probe (**HF-SOP-10**)

The following forms will be completed and retained in the project file:

- A. Water Sampling Form (**HF-FORM-430**);
- B. Chain-of-Custody Form (**HF-FORM-1**); and
- C. Shipping receipts.

6.0 REFERENCES

USGS, 1999. National Field Manual for the Collection of Water-Quality Data: Chapter A4, Collection of Water Samples. USGS TWRI Book 9, September 1999.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF pH USING A pH METER® HF-SOP-20

1.0 PURPOSE

The purpose of this procedure is to obtain accurate field measurements of the pH of water samples.

2.0 EQUIPMENT

This procedure written for Beckman pH meters is applicable to a variety of pH meters. Specific operating instructions accompanying each pH meter should be followed where in variance with the following.

2.1 INSTRUMENTS

- Beckman I-10 or I-21 pH meter or similar instrument;
- Beckman pH electrode/probe, Model 39841 or equivalent;
- Beckman temperature probe, Model 598115 or equivalent; and
- Field notebook.

2.2 REAGENTS

- Buffers pH 4.0, 7.0 and 10.0 (other buffers may be used in unusual waters);
- Deionized water; and
- Beckman filling and storage solution - 4 Molar KCl (potassium chloride).

3.0 PROCEDURE

Calibration of the instrument should be performed at least once per day, before sampling activities commence. Field calibration forms must be completed at this time, and calibration verification should be documented in field notebooks.

While field instruments are manufactured to be rugged and dependable, a reasonable amount of care is still required to ensure that instruments function properly and give accurate readings.

Field instruments must be cleaned and stored in accordance with established guidelines (see operating instructions) in order to maintain instrument integrity.

3.1 EQUIPMENT SET UP

3.1.1 Instrument Check

- Turn instrument on by pressing pH button, check display and confirm the low battery light is not illuminated; and
- Visually inspect probe for damage and fluid level. If damage is evident, replace probe. If low on fluid, refill using 4 Molar KCl potassium chloride. Be sure to leave vent hole uncovered while taking measurement so that liquid junction flows freely.

3.1.2 Connecting Electrodes

- Insert the pH electrode connector into the large input jack on the top of the instrument and twist to the locked position.
- Insert temperature electrode connector into the small input jack on the instrument top. Instrument is now ready to use.

3.2 pH MEASUREMENT

3.2.1 Select two buffers, one with a pH of 7.0. Select a second buffer (pH 4.0 or 10.0) so that the two buffers bracket the anticipated sample pH (use fresh buffers for calibration).

3.2.2 Uncap pH electrode, remove stopper from vent hole, rinse both pH probe and temp probe with deionized water and place in pH 7.0 buffer.

3.2.3 Depress the CLR button, then depress the ↓ button. The meter will automatically temperature adjust the reading and compensate to read the buffer in which it is reading. This reading will lock in memory and display on the bottom of the screen.

3.2.4 Remove electrodes from the solution. Rinse with distilled water and place in the second buffer.

3.2.5 Repeat step 3.2.3 with the second buffer.

- 3.2.6 Remove electrodes from the second buffer, rinse with distilled water then a portion of sample and place in sample. The instrument is calibrated daily or anytime a pH is measured, which is not in the buffer range for which the instrument is calibrated.
- 3.2.7 Record the pH of the sample in sample field notebook.
- 3.2.8 When measurements are complete, rinse probe with distilled water. Add a few drops of 4 Molar KCl solution to the protective cap and store probe in the protective cap. Replace cover over vent hole.

4.0 ASSOCIATED REFERENCES

Beckman Instruments, 1992. Instruction manuals for specific ion meter, models I-10, I-11, I-12; and I-21 pH meters.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF DISSOLVED OXYGEN[®]

HF-SOP-22

1.0 PURPOSE

The purpose of this procedure is to obtain accurate field measurements of dissolved oxygen (DO) in water.

2.0 EQUIPMENT

2.1 INSTRUMENTS

- YSI Model 55 Dissolved Oxygen Meter

2.2 REAGENTS

- Deionized water (DI H₂O); and
- Oxygen probe solution.

2.3 OTHER

- Flow Cell (strongly recommended)
- Field Notebook

3.0 PROCEDURE

When collecting measurements in surface water, the probe can be placed directly into the water body. **Similarly, the best method for measuring DO in groundwater is by using a downhole probe.** However, if this is not feasible, alternate acceptable methods are available. When measuring ground water, care should be taken to avoid adding oxygen to the water during sample collection. To avoid this condition, bailers should be moved slowly across the water surface and pumping rates should be reduced to avoid splashing or otherwise aerating the sample upon collection in the sample cup. Pumps which cause air to contact the water should not be used. **Use of a flow-through cell is strongly encouraged over collection in a sample cup.** A flow-through cell reduces potential sample aeration and allows for selection of a standard flow rate to proceed across the probe.

3.1 EQUIPMENT SET-UP AND CALIBRATION

- 3.1.1. Switch probe on and allow to warm up for at least 15 minutes. Check probe storage chamber to ensure that sponge in chamber is moist.
- 3.1.2. Press up and down arrow keys simultaneously to enter calibration mode. Input approximate elevation in feet above mean sea level and press Enter.
- 3.1.3. Allow meter reading to stabilize. Record "Cal #" shown in lower area of display, as well as meter readout following stabilization. These numbers should be similar (i.e., for "Cal #" equal to 82, stabilized meter reading should be 80-84). Press Enter.
- 3.1.4. Input salinity correction value (leave at 0.0 for fresh water, or input approximate salinity for brines, seawater, etc.) Press Enter. Meter is ready for use. If "Cal #" and stabilized meter reading are not similar, recalibrate.

3.2 DISSOLVED OXYGEN MEASUREMENT

- 3.2.1 Lower probe into sample. NOTE: Some motion of water past probe membrane is required, so if water sample is quiescent, manual movement of probe is required (do not aerate sample during movement).
- 3.2.2. Allow reading to stabilize. MODE key selects unit readout (% saturation or mg/L). Record reading and temperature.
- 3.2.3. Replace probe in storage chamber after decontamination. If meter is shut off, recalibration is required each time meter is turned on. Recalibration will also be required if elevation changes significantly (>200 ft) between sample locations.

4.0 ASSOCIATED REFERENCES

Yellow Springs Instrument Company. Instrument manual for YSI Model 55 dissolved oxygen meter.

HF-SOP-49 - Use of a Flow Cell for Collecting Field Parameters.

TABLE 1. SOLUBILITY OF OXYGEN IN FRESH WATER

<u>Temperature</u> <u>°C</u>	<u>mg/L Dissolved</u> <u>Oxygen</u>	<u>Temperature</u> <u>°C</u>	<u>mg/L Dissolved</u> <u>Oxygen</u>
0	14.60	23	8.56
1	14.19	24	8.40
2	13.81	25	8.24
3	13.44	26	8.09
4	13.09	27	7.95
5	12.75	28	7.81
6	12.43	29	7.67
7	12.12	30	7.54
8	11.83	31	7.41
9	11.55	32	7.28
10	11.27	33	7.16
11	11.01	34	7.05
12	10.76	35	6.93
13	10.52	36	6.82
14	10.29	37	6.71
15	10.07	38	6.61
16	9.85	39	6.51
17	9.65	40	6.41
18	9.45	41	6.31
19	9.26	42	6.22
20	9.07	43	6.13
21	8.90	44	6.04
22	8.72	45	5.95

Source: Derived from 15th Edition "Standard Methods for the Examination of Water and Wastewater".

TABLE 2. ALTITUDE CORRECTION FACTOR

Atrnospheric Pressure <u>mmHg</u>	<u>or</u>	Equivalent Altitude <u>Ft.</u>	<u>=</u>	Correction <u>Factor</u>
775		-540		1.02
760		0		1.00
745		542		.98
730		1094		.96
714		1688		.94
699		2274		.92
684		2864		.90
669		3466		.88
654		4082		.86
638		4756		.84
623		5403		.82
608		6065		.80
593		6744		.78
578		7440		.76
562		8204		.74
547		8939		.72
532		9694		.70
517		10472		.68
502		11273		.66

Source: Derived from 15th Edition "Standard Materials for the Examination of Water and Wastewater".

STANDARD OPERATING PROCEDURE

LABELING AND DOCUMENTATION OF SAMPLES® HF-SOP-29

1.0 PURPOSE

Documentation of all samples is an important aspect of the project quality assurance program. This SOP specifically describes sample labeling procedure, but also addresses related aspects of sample documentation, all or some of which may be required by the project Quality Assurance Project Plan (QAPP).

2.0 EQUIPMENT

Sample documentation will involve use of some or all of the following:

1. Sample Identification Tag or Labels;
2. Chain-of-Custody Records;
3. Custody Seals;
4. Sample Analysis Form, or cover letter and parameter list; and
5. Field Notebooks.

These documents are sequentially numbered or sequentially paged.

All forms are completed using waterproof ink. Where necessary, the sample labels are protected with label protection tape.

3.0 SAMPLE IDENTIFICATION TAGS OR LABELS

Projects which may be the subject of litigation or are mandated by the EPA typically require serially numbered Sample Identification Tags. Sample labels (generally self-adhesive) are used in lieu of Sample Identification Tags for many projects and provide the same information, but are not serially numbered. The following discussion pertains specifically to use of Sample Identification Tags but, except for the next two paragraphs, is applicable to sample labeling in general.

Sample Identification Tags are distributed to field investigators and the serial numbers are recorded in project files and the field notebook. Individuals are accountable for each tag assigned to them. A tag is considered in their possession until it has been filled out, attached to

a sample and transferred to another individual with the corresponding Chain-of-Custody Record.

At no time are any Sample Identification Tags to be discarded. If any tags are lost, voided or damaged, the circumstances are noted in the appropriate field notebook immediately upon discovery and the Quality Assurance officer notified. At the completion of the field investigation activities, all unused Sample Identification Tags are returned and are checked against the list of assigned serial numbers.

Samples are removed from the sample location and transferred to a laboratory or other location for analysis. Before removal, however, a sample is often separated into fractions depending on the analysis to be performed. Each portion is preserved in accordance with prescribed procedures and each is identified with a separate Sample Identification Tag. In this case, each tag should indicate in the "Remarks" section that it is a split sample.

The information recorded on the tag or label includes:

- **Project Code.** An assigned Hydrometrics number (optional);
- **Station Number.** A code assigned by the Field Team Leader (optional), which identifies the station location;
- **Date.** A six-digit number indicating the year, month and day of collection;
- **Time.** A four-digit number indicating the 24-hour clock time of collection (for example, 1345 for 1:45 p.m.);
- **Sample Number.** The sample code number assigned to that sample and recorded in the field notebook;
- **Samplers.** Each sampler's name;
- **Preservative.** The tag should indicate whether a preservative is used, the type of preservative, and whether the sample has been field filtered;
- **Analysis.** The general type of analysis requested;
- **Tag Number.** A unique serial number, stamped on each tag (optional); and
- **Remarks.** The sampler's record of pertinent information (sample matrix, dissolved vs. total, highly contaminated, etc.).

The tag used for water, soil, and sediment samples contain an appropriate place for designating the sample as a grab or a composite, identifying the type of sample collected for analysis, and

indicating preservation, if any. The Sample Identification Tags are attached to or folded around each sample and are taped in place.

After collection, separation, identification and preservation, the sample is handled using chain-of-custody procedures as discussed in the **Chain-of-Custody Standard Operating Procedure (HF-SOP-5)**.

If the composite or grab sample is to be split, aliquoted portions are placed into similar sample containers. Sample Identification Tags are completed and attached to each container. Tags on quality control samples (e.g. blank, duplicate, blind field standards) are NOT marked to identify samples as such.

3.1 SAMPLE CODE NUMBERING OF DUPLICATE SAMPLES FOR XRF ANALYSES

When collecting duplicate soil samples to be analyzed by XRF techniques, the duplicate sample number is the same as the original sample number with the exception of a suffix "D" designation.

For example:	XYZ-9710-100	Original Sample Number
	XYZ-9710-100D	Duplicate Sample Number

4.0 CHAIN-OF-CUSTODY

Samples collected during any investigation may be used as evidence and their possession must be traceable from the time the samples are collected until they are introduced as evidence in legal proceedings. To document sample possession, Chain-of-Custody procedures are followed. These procedures are described in the **Chain-of-Custody Standard Operating Procedure (HF-SOP-5)**.

5.0 SAMPLE SHIPMENT

Samples are packaged properly for shipment as described in the **Packing and Shipping Samples Standard Operating Procedure (HF-SOP-4)** and dispatched to the appropriate laboratory for analysis.

If sent by mail, the package is registered with return receipt requested. If sent by overnight express courier or common carrier, a Bill of Lading is used. Air freight shipments are sent collect. Freight bills, Postal Service receipts and Bills of Lading are retained as part of the permanent documentation.

When Chain-of-Custody is required, a separate custody record must accompany each shipment. When transferring samples, the individuals relinquishing and receiving samples will sign, date

and note the time on the record. This record documents sample custody transfer from the sampler, often through another person, to the analyst at the laboratory.

6.0 SAMPLE ANALYSIS REQUEST

Samples sent to a laboratory for testing will be accompanied by a Request for Analytical Services or cover letter that describe the samples, specifies the testing required, and who is to receive the analytical report. Commonly, a standard analytical schedule is used for a project and this schedule should be attached to the Request for Analytical Services or cover letter.

7.0 FIELD NOTEBOOKS

A bound field notebook must be maintained by the Field Team Leader to provide a daily record of significant events, observations and measurements during field investigations. All entries should be signed and dated. All members of the field investigation should use this notebook. It should be kept as a permanent record.

These notebooks are intended to provide sufficient data and observations to enable participants to reconstruct events that occurred during the project and to refresh the memory of the field personnel if called upon to give testimony during legal proceedings. In a legal proceeding, notes, if referred to, are subject to cross-examination and are admissible as evidence.

8.0 CORRECTIONS TO DOCUMENTATION

Unless prohibited by weather conditions, all original data should be recorded in field notebooks, Sample Identification Tags and Chain-of-Custody Records are written with waterproof ink. None of these accountable serialized documents are to be destroyed or thrown away, even if they are illegible or contain inaccuracies that require a replacement document.

If an error is made on an accountable document assigned to one individual, that individual may make corrections simply by crossing a single line through the error and entering the correct information. The erroneous information should not be obliterated. Any subsequent error discovered on an accountable document should be corrected by the person who made the entry. All subsequent corrections must be initialed and dated.

9.0 SAMPLE NUMBERING

All samples of water and earth materials will be assigned a number by Hydrometrics. The numbers assigned for water samples will all use the project prefix and will be followed by a sequential number. The first sequential number will be 1 and a total of 5000 numbers are available for project water samples. A water sample may consist of several bottles if the sample is to be analyzed for several parameters, each requiring a different preservation technique. All

bottles for a sample will have the same sample number. Sampling data including site identification and sample numbers will be recorded in the field sampler's notebook to allow positive identification of the sample.

All samples of earth materials such as drilling cores from test wells and stream bottom sediment will be assigned a number by Hydrometrics. The numbers assigned for earth material samples will use the project prefix and will be followed by a sequential number. The first sequential number will be 5001 and a total of 4999 numbers are available for these samples. Sampling data and sample numbers for earth materials will be recorded and handled in the same manner as for water samples.

The laboratory will not be aware of the specific sample source. All quality control samples will use the same sample numbering method.

10.0 ASSOCIATED REFERENCES

National Water Well Association, 1986. RCRA Groundwater Monitoring Technical Enforcement Document. September.

U.S. EPA, 1986. Test Methods for Evaluating Solid Waste, SW-846, 3rd Edition, Vol. II: Field Manual Physical/Chemical Methods. November.

STANDARD OPERATING PROCEDURE

FIELD NOTEBOOKS® HF-SOP-31

1.0 PURPOSE

Field notebooks are intended to provide sufficient data and observations to enable project participants to reconstruct events that occurred during the project and to refresh the memories of field personnel if called upon to give testimony during legal proceedings. In a legal proceeding, notes, if referred to, are subject to cross-examination and are admissible as evidence.

2.0 EQUIPMENT

Bound notebook with water resistant pages

Pen with indelible ink

3.0 PROCEDURE

A bound field notebook must be maintained by the Field Team Leader to provide a daily record of significant events, observations and measurements during field investigations. All members of the field investigation should use this notebook and initial their entries. It should be kept as a permanent record. All information called for in the Work Plan must be recorded, and any other data pertinent to the investigation at hand.

General information recorded in the field notebooks must include:

- Date and time;
- Weather conditions;
- Site name and description (if the first visit);
- Names of individuals participating in and/or observing sampling; and
- Unusual circumstances (unlocked well lid, missing staff gage, flood stage, etc.).

In addition, sampling personnel must record descriptions of sampling activities and parameters determined at each sampling station, appropriate to the type of media being sampled. This should include (but is not limited to) the following:

1) For water sampling (surface water and/or groundwater):

Water level measurement

Flow measurement

Sample collection:

Site number

Sample code number

Date and time

Bottle size(s)

Sample tag number (for Superfund investigations)

Bottle quality control number (for Superfund)

Dissolved Oxygen

Water Temperature

Specific conductivity

Calibration of Field Equipment

Preservative(s)

pH

Filtration

2) For soil sampling and/or sediment sampling:

Soil moisture conditions

Soil type (textural classification)

Sample collection

Site number

Sample code number

Date and time

Sample tag number (for Superfund investigations)

Sketch map of property, designated sample units and sample locations (for soil samples), or cross-section of stream sampled and approximate grab sample locations (for sediment samples).

Site descriptions should be adequate for someone unfamiliar with the site to relocate sampling point, and should be particularly detailed if this is the first sampling.

Other information deemed pertinent to sampling procedures and field conditions should be entered in field notebooks. This should include (at a minimum):

1. Notes confirming that calibration of field instruments (pH, SC, DO, etc.) was performed prior to sampling;
2. Notes detailing decontamination procedures performed (methods, any reagents used);
3. Notes describing the source of DI water used for decontamination or for collection of blanks; and
4. Notes describing shipment of samples to the laboratory and any enclosures included as part of such shipments (chain-of-custody, parameter lists, etc.).

All field notes should be entered into bound notebooks with indelible ink. Corrections should be made by deleting incorrect information with a single line and initialing the deletion in the field notebook. Each page should be numbered consecutively and signed by field personnel. All field records should be kept under custody of the Field Team Leader. Copies of the field records should be available for distribution to all team members for data reduction and report preparation.

STANDARD OPERATING PROCEDURE**FILTRATION OF WATER SAMPLES[®]****HF-SOP-73****1.0 PURPOSE**

Water is filtered to obtain a sample for analysis of dissolved constituents. Dissolved constituents are operational, defined as those which pass a 0.45 micron filter. This SOP describes three methods in which filtered water samples can be prepared in the field. Other types of filtering equipment can be employed. The essential points are use of the proper filter and adequate decontamination of reusable equipment.

2.0 EQUIPMENT

<u>Filter Barrel</u>	or	<u>Plate Filter</u>	or	<u>Disposable Filter Cartridges</u>
Tire pump		Peristaltic Pump		0.45 µm filter
Filter barrel		Plate filter		cartridges
Clean sample bottles		0.45 µm membrane		Peristaltic Pump
Prefilters (where needed)		filters		Plastic tubing
0.45 µm filter membranes		Prefilters (where		Clean sample bottles
Distilled or deionized water		needed)		Distilled or
Plastic tweezers		Plastic tubing		deionized water
		Clean sample bottles		
		Distilled or deionized water		
		Plastic tweezers		

3.0 PROCEDURE**A) General**

1. Have at hand clean sample bottle pre-labeled with appropriate information.
2. Use a new filter membrane or disposable cartridge for each sampling site.
3. If water is very turbid, it must be first run through a larger pore size pre-filter.
4. Be sure you know the volume of sample required for analysis, check with laboratory if in doubt.
5. If collecting samples for low level analysis, rinse filter with an appropriate amount (usually 100 to 200 ml) of DI water prior to filtering any sample. This step should

remove contaminants (particularly zinc) which may be entrained within the filter matrix. Record the amount of DI water used to rinse the filter.

6. Rinse sample bottle with filtered water three times, before collecting actual sample. However, if water is hard to filter or of limited quantity, distilled or deionized water rinses are acceptable.
7. Avoid dusty locations and vehicle motor exhaust while filtering.
8. When a peristaltic pump is used, the pump and tubing should be cleaned immediately after obtaining a sample by pumping 500 ml of deionized water. After pumping 500 ml deionized water, remove inlet tubing from DI source and continue pumping until tubing is drained.

B) Filter Cartridge These are single-use, self-contained membrane filtration devices with inlet and outlet hose barbs designed for use when samples are pumped.

1. Examine a new filter cartridge and note direction of flow arrow imprinted on it.
2. Slip hose from pump over inlet nipple of cartridge. Sample may be collected directly from filter outlet (optional, place another short piece of tubing over outlet, if this is more convenient). Keep tubing length as short as possible.
3. It is important that water flow through filter in direction of imprinted arrow, as filter failure will likely result if flow direction is reversed. Also, inlet pressure should not exceed 25 PSI (pounds per square inch) for most filters of this type.
4. Turn pump on, discard initial 30 ml of filtrate (filter purge), then begin collecting sample.

C) Filter Barrel Filter barrels are reusable plastic cylinders with removable endcaps and fitted with a replaceable filter at one end (the outlet) and an air inlet at the opposite end by which the barrel is pressurized. Filter barrels are used where samples cannot be pumped.

1. Filter barrels must be decontaminated prior to going to the field. Remove both end caps, O-rings, and filter support. Wash components thoroughly with a non-phosphate detergent and water, thoroughly rinse with distilled or deionized water, re-assemble and store in plastic bag.
2. Ideally, the filter barrel should be rinsed with the water to be sampled. If an inadequate volume of sample water is available, a distilled or deionized water rinse is acceptable.

3. After rinsing, fill filter barrel 2/3 full with sample water.
4. Place clean 0.45 μm filter on filter support (do not touch filter with hands, use plastic tweezers or blue divider papers to move or adjust filter). Wet filter support will hold filter in place.
5. Assemble filter barrel carefully so as not to twist or put folds in filter paper.
6. Turn filter barrel over so sample water comes in contact with filter paper.
7. Connect tire pump to Shrader valve and pump several times. Do not allow static pressure on tire pump to go over 20 PSI.
8. Purge filter by draining approximately 100 ml of water from lower side of filter support. Discard this initial filtrate.
9. Once sample bottle is full, preserve sample as needed and place in cooler with ice. (see HF-SOP-3, Preservation and Storage of Inorganic Water Samples).
10. Before leaving the sampling site, disassemble filter barrel, remove and dispose of filter paper, and immediately rinse with distilled or deionized water. Partial decontamination, consisting of three successive distilled or deionized water rinses between sites is acceptable.

D) Plate Filter Plate filter is a reusable membrane filter holder, generally fitted with three removable legs. The filter holder is disassembled to replace the large diameter (typically 14.2 cm) membrane filter. Water is pumped through the filter, entering at the top and exiting through a port at the bottom.

1. Plate filters must be decontaminated prior to use. Disassemble plate filter, wash components thoroughly with a non-phosphate detergent and water, thoroughly rinse with distilled or deionized water, re-assemble and store in plastic bag.
2. Ideally, the plate filter should be rinsed with the water to be sampled. If an inadequate volume of sample water is available, a distilled or deionized water rinse is acceptable.
3. Place clean 0.45 μm membrane filter on filter support (do not touch filter with hands, use plastic tweezers or blue divider papers to move or adjust filter). Wet filter support will hold filter in place.
4. Assemble plate filter carefully so as not to twist or put folds in filter paper.

5. Connect plastic tubing from pump to top hose barb on filter. Sample may be collected directly from outlet, or keep tubing lengths as short as possible. A short piece of tubing may be connected to outlet barb at bottom.
6. Purge filter by pumping approximately 100 ml of water through the filter. Discard this initial filtrate.
7. Once sample bottle is full, preserve sample as needed and place in cooler with ice. **(see HF-SOP-3, Preservation and Storage of Inorganic Water Samples).**
8. Before leaving the sampling site, disassemble plate filter, remove and dispose of filter paper, and rinse with distilled or deionized water.

NOTES

- Use a new filter membrane for each sample.
- Run very turbid or muddy water through prefilter first and then a 0.45 micron filter.
- Check with lab performing analysis for adequate quantity and holding time for sample. Complete all appropriate documentation.
- Completely decontaminate filtering equipment after each day of use and whenever partial decontamination doesn't visually clean all filter parts.
- Do not attempt filtration in dusty locations or while your vehicle motor is running (due to exhaust).

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF SPECIFIC CONDUCTIVITY® HF-SOP-79

1.0 PURPOSE

The purpose of this procedure is to obtain accurate field measurements of specific electrical conductance of water samples. This procedure is written for the Hydac Digital type meter; other meters may be used if they are calibrated and used according to manufacturer's recommendations.

2.0 EQUIPMENT

2.1 Instrument

- Hydac Digital Conductance Meter or equivalent meter.

2.2 Reagents

- Potassium Chloride (KCl) standard solutions with known conductivities: (e.g., 50, 74, 147, 400, 718, 1413, 6668, 12990 $\mu\text{mhos/cm}$ at 25°C).

2.3 Other Materials

- Distilled or deionized water for rinsing
- Field Sampling Notebook

3.0 PROCEDURE

3.1 Calibration

3.1.1 Rinse sample cup with distilled water before and after each conductivity standard used.

3.1.2 Select a standard with a conductivity value in the approximate range of the samples to be measured. After rinsing the sample cup with distilled water, rinse with the selected standard. Fill the cup with the standard, set function selector to TEMPERATURE and depress READ button. Set the temperature compensation knob on the conductivity side of the meter to the displayed temperature.

3.1.3 Switch function selector to CONDUCTIVITY and depress the READ button (READ button must be held down for display). Move the range selector to the lowest setting which will give a reading.

3.1.4 If the reading is not that of the standard, with a small screwdriver, adjust the calibration screw at the bottom of the meter (only small turns are required for fine-tuning).

3.1.5 Record reading, temperature, and time of calibration.

3.2 Sample Specific Conductivity Measurement

3.2.1 Rinse the sample cup with distilled water prior to filling with the sample. Rinse and fill with sample water.

3.2.2 Switch function selector to temperature scale and measure temperature of sample.

3.2.3 Adjust temperature compensator knob on the conductivity side of the meter to the displayed temperature.

3.2.4 Switch function selector to conductivity and depress READ button. Move the range selector to the lowest setting which will give a reading. Read conductivity and multiply by range. Record in field sampling notebook.

3.2.5 When measurements are complete, rinse probe with distilled water.

3.3 Calibration Check

3.3.1 At least once per day (or about once per every ten samples collected, whichever is more frequent), or when measuring conductivities of samples significantly different from the initial calibration solution, the meter should be checked against a standard of known conductivity. Record the check standard conductivity, temperature, and meter reading on appropriate documentation.

3.3.2 If the check standard reading differs from the true value by more than 10%, the meter should be recalibrated according to Section 3.1 of this SOP.

4.0 ASSOCIATED REFERENCES

Hydac Instruments -Instruction Manual for Digital Conductance, Temperature, and pH Tester.
Hydrometrics' Video Training Library -- Measurement of Conductivity.

STANDARD OPERATING PROCEDURE

FIELD MEASUREMENT OF TEMPERATURE[®]

HF-SOP-84

1.0 PURPOSE

This procedure outlines the protocol for measurement of water temperature in the field. The procedure is applicable to lotic systems (rivers and streams), lentic systems (lakes, ponds, reservoirs, and impoundments), and groundwater systems. Special considerations for the various types of water environments are included in this procedure.

2.0 EQUIPMENT

- Liquid-filled thermometer, with scale divisions marked at a minimum of 1.0°C;
- Standard field meter equipped with a thermometer (for example, pH meters and conductivity meters often include temperature readout option);
- Temperature readout device with a remote probe (necessary for measuring temperature at depth in lakes or groundwater wells); and
- Field notebook.

3.0 PROCEDURE

Calibrate temperature measurement devices prior to field use with NIST-certified thermometers. When two methods of temperature measurement are available in the field (glass thermometer and pH water thermometer, for example) they may be used to cross-check one another.

It is preferable to measure temperature directly in the source to be sampled by immersing the thermometer into the stream, pond, etc., and allowing the reading to stabilize, when practical. Procedures for each of the main types of water samples are given below. If temperature must be measured on a sample that has been removed from the source, it is critical to measure and record the temperature immediately after collection, since equilibration with ambient air and container temperature will immediately begin to affect sample temperature.

A. Rivers and Streams

Wade stream and measure temperature directly, or measure from bank if unwadable. Temperature should be measured at multiple points across the stream transect, especially in large, slow-moving river systems or immediately downgradient of tributaries. The average of all measurements is taken as the water temperature and recorded in the field notebook.

B. Lakes and Ponds

Measure temperature from bank and record. Recall that static water bodies often stratify. If samples are collected at various depths, temperature should be recorded at each depth. Depth profiling of temperature should occur at 1 foot or smaller intervals, in most cases.

C. Groundwater

Measure temperature of pumped or bailed water while purging well to monitor stabilization of temperature. Record temperature immediately after obtaining sample. If a remote, "down-the-hole" temperature probe is available, its use is preferred.

4.0 ASSOCIATED REFERENCES

"Standard Methods for the Examination of Water and Wastewater," 18th edition (1992), page 2-59.

STANDARD OPERATING PROCEDURE
OPERATION OF PNEUMATIC SLUG TESTER
(HF-SOP-99)

1.0 PURPOSE

The pneumatic slug tester, used in conjunction with the In-situ Troll or similar transducers, may be used for rising-head slug tests in wells where the static water level is higher than the well screen. The pneumatic slug tester uses air pressure to displace water inside the well casing. When the release valve is opened, the air pressure inside the casing instantaneously returns to atmospheric pressure and the water level rises in the well casing until it equilibrates. The Troll or similar transducer measures the water level or pressure in the well during the test. Data recorded may be processed using software such as Aqtesolv. The pneumatic slug tester was built by the Billings Hydrometrics Office and has couplings to mount on 2-inch, 4-inch, and 4 1/2-inch wells.

2.0 EQUIPMENT

- Transducer - Insitu Troll
- Laptop Computer - with WinSitu software and 12V Power Adapter
- Pneumatic Slug Tester Body
- Release Valve Assembly
- Transducer Cable Seal Assembly
- Riser Adapter Assembly (2-inch and 4-inch)
- Pressure Gauge (measurement in inches of water)
- Air Inlet Valve
- 12V Air Compressor
- 12V Power Source
- Confined-space Screw Ratchet
- 1/2-inch wrench
- Small crescent wrench
- Pipe Wrench
- String and Duct Tape

3.0 PHYSICAL REQUIREMENTS

- The static water level in the well must be a sufficient distance above the well screen to allow for reasonable displacement of the water column by compressed air. As a general rule, the static water level should be a minimum three feet above the well

screen; but in a highly permeable aquifer, three feet of water would not suffice. When the pressurized air column reaches the well screen, air escapes from the well, and additional water displacement in the casing is not possible. In this sense, the pressure inside the casing is self-regulated; however, it is preferable not to inject air into the sand pack and aquifer.

- The integrity of the casing and casing joints must be such that pressurized air cannot escape from the casing.
- The well casing (riser) must be accessible so that the rubber booting on the Riser Adapter Assembly can be placed over the riser and the metal band tightened. This can be difficult if there is limited annular space between the steel surface casing and riser pipe. Ideally, the top of the riser pipe would be at the same level as the top of the surface casing, with ample space to turn the screw of the metal band on the booting. It is difficult to tighten the metal band of the rubber booting around a 2-inch riser located several inches below the top of 4-inch surface casing.

4.0 PROCEDURE

4.1 Instrument Setup

- Identify the total depth and screened interval of the well and measure the static water level.
- Attach the Riser Adapter Assembly to the riser pipe by slipping either the 2-inch or 4-inch rubber booting over the riser. The metal band on the rubber booting must be tightened to prevent air leakage; this likely will require using a confined-space screw ratchet, which should be secured with duct tape and string so that it will not be lost down the surface casing annular space. The 4-inch to 2-inch reducer must be used when attaching the Riser Adapter Assembly to a 2-inch riser.
- Screw the Release Valve Assembly into the Pneumatic Slug Tester Body on the offshoot portion of the Y. Tighten snugly with hands so that air cannot escape via the treads. Excess tightening will result in stripped threads and difficulty in removal.
- Attach the Pneumatic Slug Tester Body to the Riser Adapter Assembly by pushing the bottom male end into the 4-inch rubber booting. Tighten the metal band on the rubber booting to prevent air leakage.
- Unscrew the compression fitting tightener and remove it and the rubber stopper from the Transducer Cable Seal Assembly.
- Pass the computer plug-in end of Troll cable through the bottom end of the Transducer Cable Seal Assembly and through the compression fitting tightener.

- Lower Troll Probe into well to approximate desired depth.
- Pull excess Troll cable away from the well through the opening in the Transducer Cable Seal Assembly.
- Adjust the Troll probe to its final level in the well. For a reference point, wrap some tape around the Troll cable slightly above the point the cable will exit the Transducer Cable Seal Assembly. The probe must be placed below the maximum displacement of water by pressurized air. The probe should not be placed too close to the point of maximum water displacement. The probe should not be placed against the bottom of the well.
- Insert the cable into the split rubber stopper below the reference mark (tape). Push the stopper into the compression fitting on the Transducer Cable Seal Assembly as tightly as possible so that air will not escape when the casing is pressurized.
- Screw on the compression fitting tightener and hand-tighten. While it is desirable to have as much compression as possible on the Troll cable, removing the compression fitting tightener is awkward and could require assistance from a pipe wrench. This step and the previous step are the most difficult and crucial steps in setting up the pneumatic slug tester.
- Attach the Transducer Cable Seal Assembly to the Pneumatic Slug Tester Body by pushing the rubber booting of the Transducer Cable Seal Assembly over the male end of the body. Tighten the metal band on the rubber booting to prevent air leakage.
- Screw the Air Inlet Valve into the brass fitting on the side of the Pneumatic Slug Tester Body. Tighten air valve lightly using a 1/2-inch wrench and small crescent wrench so that air cannot escape via the treads. Movement of the brass fitting on the Pneumatic Slug Tester Body should be avoided so that plastic threads are not stripped.
- Screw the Pressure Gauge into the brass pressure gauge port on the Pneumatic Slug Tester Body. Tighten air valve lightly using a 1/2-inch wrench and small crescent wrench so that air cannot escape via the treads. Movement of the brass fitting on the Pneumatic Slug Tester Body should be avoided so that plastic threads are not stripped.

4.2 PNEUMATIC SLUG TEST

- Hook up the Troll cable to laptop computer.
- Start WinSitu program. Activate communication between the Troll Probe and the laptop.
- Create test. Set up test parameters so that only inches or feet of water are measured. The software automatically will measure water temperature; this must be switched off. Adjust settings on the Troll using the WinSitu software for the proper units and logarithmic measurement. Choose the immediate start mode.
- Check probe reading and make calculations using the estimated depth of probe and the static water level to validate the probe reading.
- Determine size of air slug (water displacement) to be used in test.
- Close release valve.
- Set and record the reference reading.
- Hook up compressor hose to slug tester air valve.
- Turn on compressor and monitor the pressure gauge.
- Turn off the compressor when the pressure gauge reads the distance (inches of water) desired for the air slug test. Allow the well to equilibrate. The pressure gauge reading will fall, and the pump must be restarted. The compressor must be restarted multiple times until the pressure gauge reading becomes stable at the desired water displacement.
- Check all sealed points of the slug tester for air leaks. Air leaks will be detected by observations of the pressure gauge and by careful listening. The pressure gauge will not stabilize if there are air leaks. Air leaks are most likely to occur at the compression fitting / rubber stopper interface or at the rubber booting(s) on the Riser Adapter Assembly. Air leaks on the rubber bootings can be fixed by adjusting the position of the slug tester or by tightening the metal bands. If air is leaking from Troll Cable Seal, the pressurized air must be released by opening the release valve (keep eyes and ears clear of the air flow path). Then the rubber stopper on the Troll Cable Seal and the compression fitting tightener must be readjusted and the slug tester pressure tested again.
- Take continuous probe readings using WinSitu. The well has not stabilized until the probe readings are steady and match the reference reading made prior to pressurizing

the well (under ideal conditions). Realistically, equilibration exists when the probe readings stabilize; those readings may not match the initial reference reading but will be close. Time required to reach equilibration is a function of aquifer permeability. An aquifers with low permeability requires more time than an aquifer with higher permeability.

- Reset and record the reference reading and pressure gauge reading. The slug volume is equivalent to the annular space area multiplied by the displacement of water (pressure gauge reading).
- Start test on laptop.
- Pause 3 seconds before opening Release Valve. Keep eyes and ears out of the air flow path. Minimize movement of the slug tester before, during, and after opening the valve when opening the release valve. If conditions are windy, the pickup or other vehicle should be parked to block the wind.
- Monitor the probe readings using the WinSitu program.
- When the probe readings approach the reference reading, the test can be stopped. Aquifer permeability controls test duration.
- Examine recorded data.
- Save the test data and convert it to a spreadsheet file.
- Repeat the test if necessary.

5.0 DATA QUALITY

Data should be examined in log form (time) using the WinSitu software before removing and dismantling the pneumatic slug tester. The recorded maximum displacement should be similar to maximum displacement recorded by the pressure gauge. Oscillations in initial readings are normal. One or two straight-line patterns should be recognizable. Look for irregularities that could be caused by movement of the slug tester. If there are doubts about the quality of the data produced, repeat the test. In general, setting up and dismantling the equipment takes considerably more time than the actual pneumatic slug test.

6.0 SPECIAL MAINTENANCE

The Pneumatic Slug Tester is essentially maintenance-free. If the pressure gauge is exposed to moisture or very moist conditions, it should be examined and possibly recalibrated by a gauge technician. The rubber stopper on the Troll Cable Seal Assembly may need to be

replaced occasionally. This will require drilling a hole in a solid rubber stopper, making an incision on one side of the stopper to provide access for the cable to the hole, and possibly widening the hole with a rat-tail file.

STANDARD OPERATING PROCEDURE

LOW FLOW SAMPLING OF MONITORING WELLS FOR INORGANIC PARAMETERS[®] HF-SOP-105

1.0 PURPOSE

Applicability. This procedure describes the low flow sampling method to be used in the collection of groundwater samples from wells. The procedure is designed for wells where inorganic constituents are of primary concern. The goal of this method is to create a "passive" approach to water sampling where the intake velocity of the sampling device is less than or equal to the natural groundwater flow velocity. In contrast to the traditional 3-5 well volume purge method, this ratio is necessary to reduce sample disturbance and minimize purge volumes.

Limitations. This procedure is not designed to effectively sample organic compounds or liquids with a density different than water because of the discrete sampling nature of this method. There may also be complications when comparing these results to results from "traditional" 3-5 well volume purge methods from the same source. Refer to Appendix 1 for additional limitations. This method should **only** be instituted if low flow parameters are initially developed for each monitoring well at a site (see Appendix 2). While this method is designed to reduce sample disturbance and minimize purge volumes, it does not imply reduced sample times. Sampling time is dependent on the low flow parameters of the aquifer being sampled and the sampling methods being used (see Appendix 2).

2.0 EQUIPMENT

Submersible pump and electric water level probe. Other sampling equipment may be required for specific tasks. Other general equipment may include:

- Small gauge flow cell;
- pH meter;
- Turbidity meter;
- Specific Electrical Conductivity meter;
- Trip Blank (this is supplied in advance by the laboratory);
- Distilled water;
- Sampling sheets;
- Sampler's notebook;

- Coolers;
- Preservatives;
- 0.45 μm filter apparatus with inert filters;
- Paper towels;
- Properly cleaned sample containers; and
- Stopwatch or watch with second hand.

3.0 PROCEDURE

Hydrometrics Methodology. This method has been developed from internal protocols and experience as well as published guidelines. Dedicated pumps and sampling systems are recommended with this method to reduce the turbidity in the water and to reduce the time it takes to get a representative water sample. Dedicated pumps are especially important for long term monitoring programs.

Pre-sampling Considerations. The development of low flow parameters for the aquifer must be defined for each well as outlined in Appendix 2). This method is strictly dependent on the aquifer properties (such as T), and the sampling methods used (pump rate, flow cell volume, sampling interval, depth of sample, length of tube, etc.) Refer to Appendix 2 for a further discussion of the development of the low flow sampling parameters because parameters may vary by well and sampling method.

- A. Unlock and open well.
- B. Obtain water level (see water level **HF-SOP-10**).
- C. If non-dedicated equipment is used to sample the well, record depth at which sampling system is set and cross check this value with that specified in the site monitoring plan (see Appendix 2). Care should be taken to minimize disturbance when inserting sampling system into well.
- D. Micro-purge well with appropriate water removal device using the prescribed flow velocity as specified by the site monitoring plan for the particular well (see Appendix 2 for the development of a site monitoring plan). Measure the static water level to insure that no significant drawdown (greater than two tenths of a foot) is being induced by the prescribed pumping rate.

- E. Measure water quality parameters like specific electrical conductivity, pH temperature, and turbidity to determine when water quality is representative of the aquifer. Published articles (*Puls and Powell, 1992, & Puls, 1994*) suggest that when consecutive water quality values are within 10% of each other that this water is representative of the aquifer. Criteria should be outlined by the site sampling monitoring plan as prescribed in Appendix 2. These field parameters will be measured during purging and will be recorded on the Stabilization Test Form (**HF-FORM-501**).
- F. Discharge during purging is directed to a bucket or container to determine purge volume. Purge volume and equilibrium water quality values should be recorded on the Stabilization Test Form (**HF-FORM-501**).
- G. Samples are collected after field parameters have stabilized. Bottles are filled directly from discharge from the well or from another clean container. Care should be taken to minimize entrainment of air.
- H. After the bottles are filled, the appropriate preservatives are added, as required. If filtration is required, the sample is filtered into the sample bottle prior to adding any preservative, as required.

4.0 DECONTAMINATION

If cross contamination of sampled wells is a potential problem, the following procedure should be followed:

- A. Design sampling to proceed from the best quality water to the poorest quality water.
- B. Rinse the pumping apparatus between holes with a secondary water source if well yields are too low to supply sufficient water to purge the pump and hose.

If contamination is a problem, then separate pumps should be used to ensure the samples are representative of site conditions (see Decontamination of Sampling Equipment **HF-SOP-7**).

5.0 ASSOCIATED DOCUMENTS

The following documents will be completed and retained in the project file:

HF-FORM-430	Water Sampling Form
HF-FORM-1	Chain-of-Custody Form
HF-FORM-501	Stabilization Test Form

Shipping receipts.

6.0 REFERENCES

- Kearl, Peter M., Korte, Nic E., Stites, Mike, and Baker, Joe. 1994. Field Comparison of Micropurging vs. Traditional Ground Water Sampling. Ground Water Monitoring and Remediation. V. 14 N. 3.
- Puls, Robert W., and Barcelona, Michael J. 1996. Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures. Ground Water Issue. EPA/540/S-95/504.
- Puls, R.W. 1994. Groundwater sampling for metals. Environmental Sampling for Trace Analysis. Chapter 14, ed. B. Markert. Weinheim, Germany. VCH Publ.
- Puls, R.W. and R.M. Powell, 1992. Acquisition of representative groundwater quality samples for metals. Ground Water Monitoring Review 12, no. 3: 167-76.

7.0 SELECTED BIBLIOGRAPHICAL SKETCHES

- P.M. Kearl is a research scientist at Oak Ridge National Laboratory (Environmental Sciences Division, Grand Junction Office, Grand Junction, CO 81502)
- R.W. Puls is a scientist at the R.S. Kerr Environmental Research Laboratory (RSKERL), in the research division of the U.S. EPA Subsurface Systems Branch (Ada, OK 74820).

8.0 APPENDIX

APPENDIX 1

DISADVANTAGES OF LOW FLOW SAMPLING OF MONITORING WELLS

- Flow cells not small enough to sample low fluxes properly.
- Due to the discrete nature of this method, the pump rate may be too low to get a representative groundwater sample of the entire aquifer for aquifers of large thickness.
- If method (traditional vs. micro-purge) is switched during monitoring period then new data may not be directly comparable to old data.
- If sample interval or flow rate is changed during monitoring program then new data may not be consistent.
- Because low flow sampling protocols are designed for laminar flow from the aquifer into the sample system, this method samples only discrete sections of the well screen. Therefore the depth of the sample interval must be recorded for each monitoring period when temporary sampling systems are used.
- For wells with large screen lengths, micropurging only samples discrete sections of the aquifer.
- A low flow sampling program requires additional setup of dedicated sampling equipment for each well for optimum sampling methods.
- Use of non-dedicated pumps potentially introduces turbidity during installation requiring additional time for settling of suspended solids.
- In some cases sample consistency may not be maintained unless a dedicated sampling system is installed in the wells.
- A low flow sampling protocol for each monitoring site must be initially developed to specify a purge rate and sampling depth for each well that is less than or equal to the natural flow rate to that particular well (see Appendix 2).
- Collecting water samples can be time consuming at a rate of 100 ml/min.

ADVANTAGES OF LOW FLOW SAMPLING OF MONITORING WELLS

- Micropurging can decrease turbidity.
- Micropurging reduces the amount of purge water.
- Micropurging can lower the amount of dissolved or suspended metals in the sample to a more representative value.
- Water samples taken directly from well screen are representative of the groundwater in the aquifer (not of well).

- For deep wells with large screens the determination of concentration gradients and contaminant present may be diluted by "traditional" methods that mix discrete plumes with water from uncontaminated intervals within the aquifer. Whereas discrete, low flow sampling should more accurately sample the target region of the aquifer.
- For long screen intervals or multiple screen intervals, several discrete water samples can be taken to determine the vertical distribution of water quality for accurate spatial delineation of the contaminant problem.
- Micropurging methods sample only the mobile fraction of water and particles.
- Some states and EPA programs prohibit filtration for metals analysis due to potential sampling artifacts, so inherently turbid water may require a low flow sample method.
- Studies of water quality parameters like dissolved oxygen, specific conductance, redox potential and turbidity, indicate that the purge volume (the amount of water removed before water quality parameters stabilize) is independent of the casing volume, implying that traditional methods using fixed purge volumes are inherently flawed.

APPENDIX 2

METHOD FOR DEVELOPING LOW FLOW SAMPLING PARAMETERS

1.0 PURPOSE

Due to the discrete nature of low flow sampling and the importance of pump rates being less than or equal to aquifer flow rates (in order to maintain laminar flow and minimize sample disturbance), low flow sampling rates, depths and protocols must be defined for each monitoring well. The initial development of these parameters and a sampling protocol is costly at the onset of a monitoring program, but may provide a better understanding of the groundwater system being monitored and greater control over data collection.

2.0 LOW FLOW SAMPLING PARAMETERS

Prior to initiating a low flow sampling program, sampling parameters need to be developed for each well. These parameters include the following:

- Depth of sampling interval;
- Pump rate;
- Reference water quality parameters;
- Purge volume; and
- Metals or compounds that are being tested in monitoring well.

3.0 EQUIPMENT

- Turbidity meter;
- pH meter;
- Small gauge flow cell;
- Sampling sheets;
- Sampler's notebook;
- Stopwatch with second hand;
- Sampling tube;
- Electronic water level probe;
- Water level measurement form; and
- Probe calibration data.

4.0 METHODS

Depth of Sampling Interval. The sampling interval must be set for each monitoring well because of the discrete nature by which this method samples water from the aquifer. Once a depth to sampling interval is specified, this depth should not be changed, even by a tenth of a foot because of potential heterogeneities in aquifer properties and water quality. Factors to consider when establishing a sample depth are: seasonal variations in static water level (SWL), whether the aquifer is confined or unconfined, screen length, hydrogeologic data, depth from SWL to screened interval, total depth of well, and the flow properties of the water quality constituents that will be monitored at the well.

1. Determine *a priori* any fluctuations in the water table caused by runoff or surface water, changes in weather patterns, transportation, change of season, growing season (ET), tides, or construction.
2. Set sampling interval at the midpoint of the well screen unless this is above the SWL at any time during the year or monitoring period, or unless the chemical species being monitored by the well are concentrated at a different depth. The change in aquifer properties over the screened interval should also be taken into consideration as should cases where a stratified aquifer is connected to contaminant source areas.
3. Record the measuring point and depth to sampling interval. Set up permanent sampling system at this time if one is being used at the site.

Pump Rate. Published values of low flow pumping rates vary from 1L/min to 100 ml/min. This is a very low rate and is designed to sample water from the aquifer at natural groundwater flow rates. Natural flow rates vary from aquifer to aquifer so it is necessary to determine these values for each monitoring well and sampling depth.

1. Samples should be taken from dedicated sampling devices such as bladder or submersible pumps. Dedicated sampling tubes should be used with peristaltic pumps. No bailers should be used.
2. Measure the SWL as a function of the flow rate to determine the limit at which drawdown is greater than 0.2 feet. If this threshold is greater than 1L/min then use 1L/min as the maximum flow rate for sampling the well. If this threshold is less than 1L/min then the purge rate should be between 50% and 80% of the pump rate that perceptibly affects drawdown.
3. Record the pump rate that stresses the aquifer value and the pump rate at which samples will be collected at the well.

Reference Water Quality Parameters. Reference water quality parameters are necessary to determine the volume of purge water that must be evacuated from the sampling apparatus in order to obtain a representative sample of the aquifer.

1. Review all available water quality data to determine water quality versus depth. Consider the most permeable area of the aquifer to be sampled as well as the most contaminated unit.
2. Measure turbidity, specific conductivity, pH, and temperature for the purge water and record these values.
3. Collection rate of these parameters is a function of the replacement time of the flow cell. Collection of these parameters can start soon after the setup of the sampling apparatus.
4. When consecutive values for each of these water quality parameters only vary within 10% of each other over twice the replacement time of the flow cell, then the sample water should be representative of the aquifer. For example, if the flow cell is 1 liter in size and the pump rate is 100 ml/min, the water quality parameters must be within 10% of each other over a 20 minute period.
5. Record the volume of purge water removed when the water quality parameters have stabilized.
6. In situations where long term monitoring has been conducted using traditional sampling techniques, it may be desirable to collect and compare samples using both methods.

Volume of Purge Water. According to published studies (*Puls and Powell, 1992, & Puls, 1994*) purge volume is independent of casing size or well volume. Therefore it is imperative that water quality parameters be sampled and the volume of purge water be recorded when these reference parameters are in equilibrium.

1. The sample pump and tubing should be "micropurged" approximately two volumes to ensure the complete removal of stagnant water. It is not necessary to purge the well casing and the screen.

Metals and Chemical Compounds. The metals or chemical compounds for which the monitoring well has been installed to evaluate should be known by the operator. Some familiarity about the flow characteristics and specific gravity of the sample metals or compounds should be understood in order to conceptualize the mobility and flow behavior of the constituents being monitored.

Record Values. All sampling depths, measuring points, and purge velocities as well as equilibrium values for turbidity, pH, and temperature must be tabulated in one location for each site or monitoring program. These results must be made available to the site manager and all persons working with these data.

5.0 REFERENCES

- Puls, R.W. 1994. Groundwater sampling for metals. Environmental Sampling for Trace Analysis. Chapter 14, ed. B. Markert. Weinheim, Germany. VCH Publ.
- Puls, R.W. and R.M. Powell, 1992. Acquisition of representative groundwater quality samples for metals. Ground Water Monitoring Review 12, No. 3: 167-76.

STANDARD OPERATING PROCEDURE

RINSATE BLANK COLLECTION[®]

HS-SOP-13

1.0 PURPOSE

The purpose of this procedure is to collect Quality Control blanks that can be used to assess the potential for sample cross-contamination.

2.0 EQUIPMENT

Sampling equipment to be tested
Field Notebook
Carboy with deionized water
Plastic catch basin

Surgical gloves
Sample bottles
Chain-of-Custody documentation

3.0 PROCEDURE

Collection and analysis of rinsate (equipment) blanks is intended to provide information on the contamination and cross-contamination potential introduced by sampling equipment and methods. Any surfaces which contact samples may contribute analytes of interest to the sample, thereby creating the possibility of positive bias in analytical results. Decontamination procedures (see **HF-SOP-7**) have been designed to minimize the likelihood of sample contamination. The effectiveness of decontamination of sampling equipment is monitored by rinsing equipment with deionized water, and measuring the concentration of parameters of interest in the resulting "blank" sample.

In general, any equipment used to collect, composite, or store samples that directly contacts the sample should be subjected to the rinsate blank procedure. Examples include pumps, filters, bailers, bottles, coring devices, shovels, trowels, and large containers used for compositing a number of samples. Other items may also require decontamination and testing through collection of rinsate blanks. The following steps describe basic rinsate blank collection procedures. Specific methods used should be documented in field notebooks whenever rinsate blanks are collected.

1. Obtain sample equipment and be sure it has been decontaminated using appropriate procedures in **HF-SOP-7** (Decontamination of Sampling Equipment).
2. Run about 50 mLs of water through carboy spigot to clean it out before collecting blank sample.

3. Place the equipment under the carboy spigot and inside the catch basin. The catch basin can be made by cutting the top off a sample bottle.
4. With surgical gloves on, open the spigot and run water over and/or through the sampling equipment. The water should contact the area of the equipment that is likely to contact the material to be sampled. Use only enough DI water to completely rinse the equipment surface. Excessive volumes of rinse water can dilute chemical concentrations in the rinsate blank, with a resulting loss of information.
5. Obtain enough water in the catch basin for the desired analysis.
6. Carefully pour water from the catch basin into the appropriate sample container for the parameters of interest, and add any necessary preservatives.
7. Document rinsate procedures in field notebooks, including a list of equipment rinsed, volumes of deionized water used, and the source of the deionized water.

APPENDIX B

EPA PROTOCOL FOR DMLS SAMPLING

To be obtained from the E.P.A.

EXHIBIT 1

GEOLOGIC CROSS SECTIONS

TARGET SHEET
EPA REGION VIII
SUPERFUND DOCUMENT MANAGEMENT SYSTEM

DOCUMENT NUMBER: 1068966

SITE NAME: EAST HELENA RCRA CORRECTIVE ACTION

DOCUMENT DATE: 04/04/2002

DOCUMENT NOT SCANNED

Due to one of the following reasons:

- ☐ PHOTOGRAPHS
- ☐ 3-DIMENSIONAL
- ☒ OVERSIZED
- ☐ AUDIO/VISUAL
- ☐ PERMANENTLY BOUND DOCUMENTS
- ☐ POOR LEGIBILITY
- ☐ OTHER
- ☐ NOT AVAILABLE
- ☐ TYPES OF DOCUMENTS NOT TO BE SCANNED
(Data Packages, Data Validation, Sampling Data, CBI, Chain of Custody)

DOCUMENT DESCRIPTION:

EXHIBIT 1 GEOLOGIC CROSS SECTIONS DRAWING
